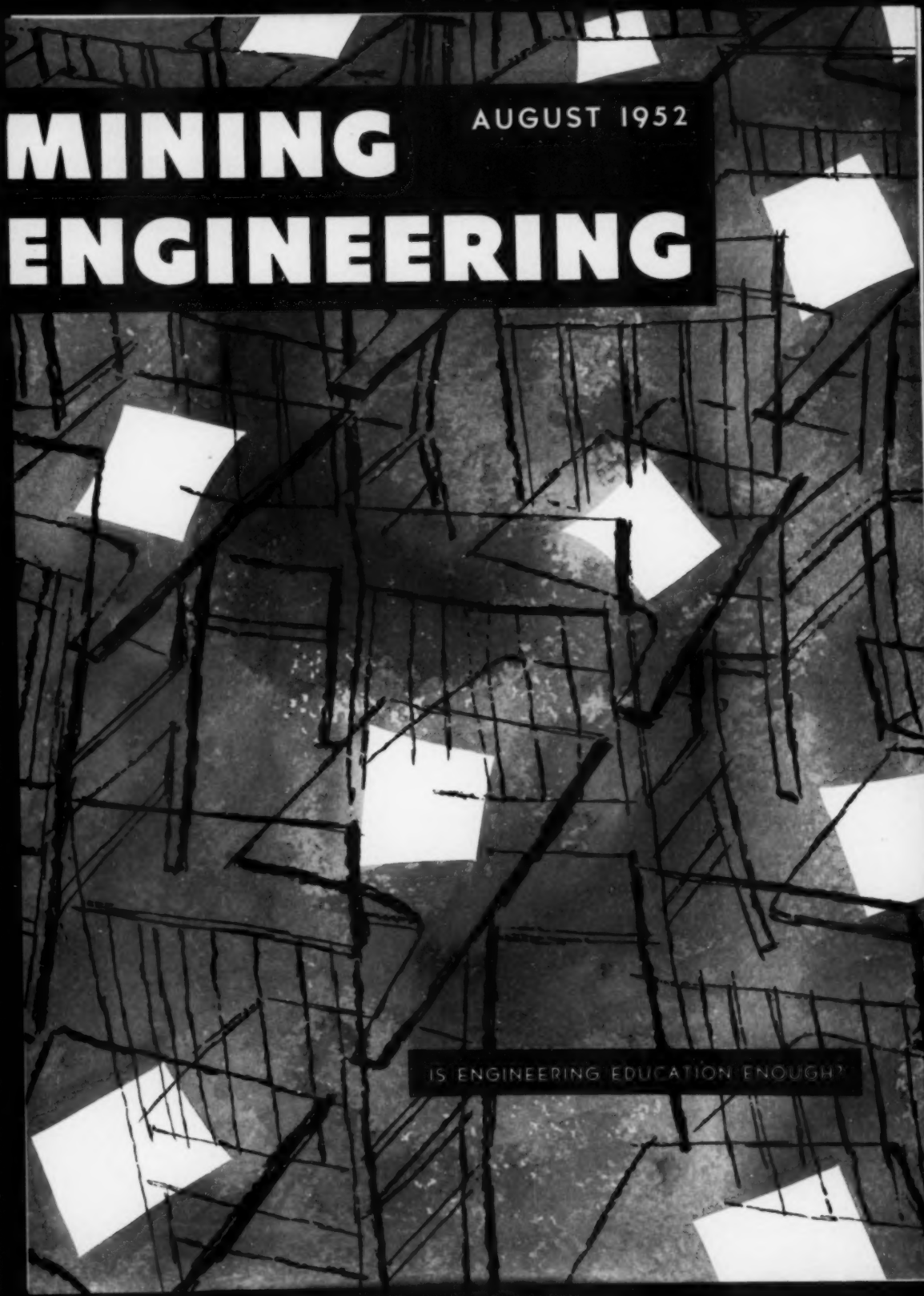
MINING ENGINEERING
AUGUST 1952
IS ENGINEERING EDUCATION ENOUGH?

WILFLEY
centrifugal PUMPS

30 acres 2 miles

• ***Wilfley Special High Head Sand Pumps*** play an important role in the successful reclamation program of the Hawaiian Commercial & Sugar Co.

• Each year, at the Puunene Mill, 30 to 40 acres of useless, sandy waste land are transformed into productive ground for sugar cane cultivation.

• Soil, removed from mechanically harvested cane by washers, is settled to a sludge of 15% to 25% solids. This sludge, together with a sludge of repulped filter cake, is pumped to the diked waste area. When dry, there remains a 2 to 3-ft. layer of reclaimed cultivable topsoil over the coral sands.

• WILFLEY Pumps, operating on a 24 hour-a-day, trouble-free schedule perform the tremendous task of delivering 300- 500 G.P.M. of cane washer wastes through 2 miles of 6" pipeline to the reclamation area. As a result, wastes which formerly presented a costly disposal problem, are now converted into revenue-producing land

Wilfley Special High Head Pumps in operation at the Puunene Mill of the Hawaiian Commercial & Sugar Co.

Buy rugged, heavy-duty Wilfley Pumps whenever the job calls for the efficient and economical handling of sludges, slimes, slurries or sands. The new WILFLEY Model "K" Centrifugal Sand Pump, embodying many important mechanical improvements, delivers higher efficiencies, stepped-up production, worthwhile power savings and lower operating costs. Easy interchangeability of wear parts. Low maintenance costs. Every application individually engineered. Write or wire for complete details.

A. R. Wilfley & Sons, Inc.
Denver, Colorado, U.S.A.
New York Office: 1775 Broadway, New York City

Buy WILFLEY for cost saving performance

Companion to the famous WILFLEY Acid Pump

Upper: Reclaimed land under cultivation.
Center: Diked reclamation area.
Bottom: Waste land to be reclaimed.

MINING ENGINEERING

Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 4 NO. 8 AUGUST, 1952

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The AIME publishes { Mining Engineering / Journal of Metals / Journal of Petroleum Technology

Published monthly by the American Institute of Mining and Metallurgical Engineers, Inc., 29 West 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S., C North, South & Central America; $9 foreign; $6 for AIME members, or $4 additional in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology" Single copies $.75; special issues $1.50. The AIME is not responsible for any statement made or opinion expressed in its publication.

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Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Entered as second-class matter Jan. 18, 1949, at the post office at N. Y., N. Y., under the act of March 3, 1879. Additional entry established in Manchester, N. H. Member, ABC.

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— Personnel Service —

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 100 Farnsworth Ave., **Detroit**; 57 Post St., **San Francisco**; 84 E. Randolph St., **Chicago 1**. Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Sales Engineer, 37, seven years experience Europe and Latin America both in underground work and administrative and sales work; speaks fluent Spanish, Portuguese, French. Desires responsible position preferably export in U. S. M-692.

Superintendent, 46, married. Experience covers mining and metallurgy as mining engineer and as general superintendent; metallurgy of leaching, flotation, cyanidation; development, construction, operation. Presently available. Prefer U.S.A. M-693-333-E-1-San Francisco.

Mine Manager, Superintendent, Consultant, 61, married. Design and erection of mining and mill plants—examinations. Many years as superintendent, manager, consultant, designer and builder of mining plants, flotation mills, concentration mills. Available one month's notice. Prefer U. S. but foreign acceptable if good climate. M-695-4211-E-9-San Francisco.

POSITIONS OPEN

Mining Engineers experienced in design, layout and cost estimating for new mines and production plants. Should be capable of supervising construction on all such projects. Must have rather broad practical and technical knowledge of mining and milling operations. Salary, $6000 to $6600 a year. Occasional travel. Location, Texas. Y6976.

Chief Engineer, mining graduate preferred, but will consider civil or mechanical with about ten years' experience, to include either construction or underground operations. Mining is open-pit but transportation problem is involved so should have some experience in mechanized operation. Transportation paid; housing available; salary open. Location, West Indies. Y7180.

Engineers. (a) Assistant Mine Engineer for underground surveying, miscellaneous underground engineering problems. Engineering degree desirable, mine experience desirable. Salary, $3900 a year. (b) Mining Methods Study Engineer, for methods and time studies of ore handling, drilling, blasting, and some mine planning. Mining degree essential, mine experience essential. Salary, $4200 to $4800 a year. (c) Technical Assistant to Mill Superintendent for metallurgical testing, metallurgical calculations and design of minor alterations to mill. Position may lead to a supervisory assistant to mill superintendent. Salary open. (d) Junior Electrical and Mechanical Engineer, to inspect underground mining equipment and supervise electricians and mechanics in maintenance of electrical and mechanical equipment. Will act as assistant to maintenance superintendent. Technical training and some practical experience necessary. Interest in mining essential. Salary open. Location, New Jersey. Y6958.

Teaching Personnel. (a) Assistant Professor in mining engineering, 25 to 35, with some practical and/or teaching experience, to teach mining engineering. Salary about $4000 for nine months depending on training and experience. (b) Instructor with some practical experience, to teach mining engineering. Opportunity for graduate work. Salary about $3500 for nine months depending on experience. Location, West. Y6952S.

Recent Graduate Engineer, mining, preferably with one year's experience in industry, to start in purchasing department on purchase of mining and industrial equipment. Salary, $4200 to $4500 a year. Location, New York, N. Y. Y6862.

Field Geologist or Mining Engineers for a two year exploration project for tin placer deposits in Brazil. Y6719.

Engineers. (a) Mine Foreman with at least three years' underground experience for lead-zinc operation. Salary, $4800 a year plus housing and family accommodations. (b) Shift Boss preferably engineering graduate, with underground experience. Salary, $4200 a year plus housing and family accommodations. Must speak Spanish. Location, Peru. Y6879.

Ore Geologist or Mining Engineer with experience in surveying primary and alluvial deposits to take charge of an expedition making a survey of tin ore deposits. Salary open. Location, South America. Y7231.

Mill Superintendent to take charge of a 100-ton flotation gold mill. Must speak Spanish. Elevation, 9000 ft. Salary open. Location, Argentina. Y7216.

Recent Graduate in ore mining, to handle surveying, mapping, geology and the laboratory for new manganese mine and mill in Virginia. Y6985.

PROFESSOR OF MINING ENGINEERING

To head Department of Mining Engineering and act as Associate Director of the Experiment Station. Desire man with both teaching and practical experience. Prefer education through Master's Degree. Salary commensurate with experience and general qualifications. Send letter of application including summary of education and experience to:

W. E. Wilson, President
South Dakota School of Mines and Technology
Rapid City, South Dakota

OUTSTANDING OPPORTUNITY

The rapid expansion of the Kaiser Aluminum and Chemical Corp. has created permanent supervisory position in Jamaica, British West Indies, for man with B.A. degree in chemistry or equivalent analytical laboratory experience in ore dressing or metallurgy. Experience in industry handling siliceous materials desirable. Salary open. If interested forward complete details of experience, education and family status to Personnel Dept., Room 100, 1924 Broadway, Oakland 12, Calif.

SUPERVISOR
EXTRACTION METALLURGY RESEARCH

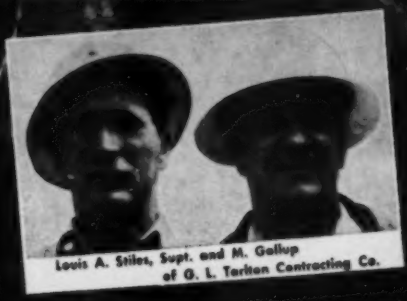
Excellent opportunity for experienced metallurgical or chemical engineer to organize and direct important program in extractive metallurgy. Graduate study in this field or the equivalent and practical experience desired; interest in and knowledge of modern research methods required. Permanent position in outstanding research laboratory offers unusual opportunity for personal and professional advancement. Salary commensurate with qualifications.

Box E-11 MINING ENGINEERING

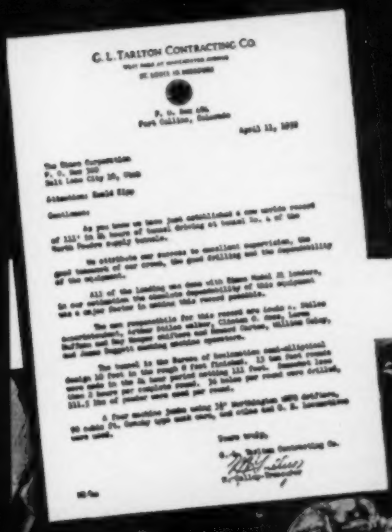
NEW ORES DISCOVERED. WYOMING. One telluride vein 7 ft. wide, assaying $37.10 in gold to $49.70 in silver. Two hornsilver veins, one 4 ft. 9 in., one 8 ft. Three galena veins, one 2 ft. wide; one 4-in., and one 8-in. vein. All widths given from outcrop on surface, assaying $200 up to $300; 22 to 120 oz. of silver, lead 80 to 86%. Require $150,000 for equipment and payroll. Only two weeks' work necessary to get ore in tunnels. Sixty miles to railroad.

H. S. HARDEE
446 S. Linden Ave.
Sheridan, Wyoming

DO YOU REQUIRE A MANAGER OR DIRECTOR
of
Operations and Explorations
Excellent Record and References
(Employed)
Box E-12 MINING ENGINEERING



Louis A. Stiles, Supt. and M. Gallup
of G. L. Tarlton Contracting Co.



G. L. TARLTON CONTRACTING CO.

P. O. Box 436
Fort Collins, Colorado

April 13, 1952

The Eimco Corporation
P. O. Box 300
Salt Lake City 10, Utah

Attention: Ewald Klop

Gentlemen:

We are happy to have just established a new world's record of 111' in 24 hours of tunnel driving at tunnel No. 4 of the North Poudre Supply Tunnels.

In attributing our success to excellent supervision, the good teamwork of our crews, the good drilling and the dependability of the equipment.

All of the loading was done with Eimco Model 21 Loaders, and in our estimation the outstanding dependability of this equipment was a major factor in making this record possible.

The men responsible for this record are Louis A. Stiles Superintendent; Foreman Stiles whose Citizen's Name is Louis Stiles and his brother Miller whose name is Gallup, William Foley, Ted Jones Dagget's loading machine operators.

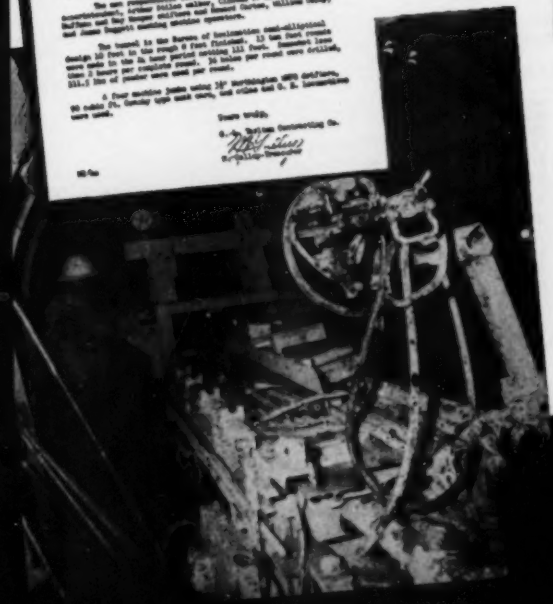
The tunnel is the Bureau of Reclamation cast-elliptical design 20 feet in the rough 9 feet finished. 12 man feet round were made in the 24 hour period yielding 111 feet. 36 holes per round were drilled, time spent per complete round. 36 holes per round were drilled, 111.1 lbs of powder were used per round.

4 Four machine jacks using 30" Worthington AMH drifters, 30 cubic ft. Sullair type unit were used, and other Gal G. E. Locomotives were used.

Yours truly,

G. L. Tarlton Contracting Co.

By: [signature]
G. Gallup-Foreman



A NEW WORLD'S RECORD FOR HIGH SPEED TUNNELING

The G. L. Tarlton Company, contractors for U.S.B.R. on the North Poudre Supply Tunnel, drove 111 ft. of 9' 4" semi-elliptical tunnel in 24 hours, April 10, 1952; thus establishing a new world's record for footage driven in 24 hours, and beating the old record by more than 6 feet. The loading job was done by Eimco Model 21 Loaders. Other specifications of the job follow: Average depth of round drilled — 10'; Steel — all 10' lengths; Bits — carbide insert, detachable type; Drills — 4 at face, 1 spare; Cars — 91 cu. ft. granby type; Holes per round — 36; Rounds this day — 13; Time of rounds, average — 35%—Drilling, 15%—Loading, 15%—Powder fumes exhausting, 35%—loading; Formation — Sundance Sandstone, Lykins formation.

EIMCO 4301

THE EIMCO CORPORATION

The World's Largest Manufacturers of Underground Rock Loading Machines

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NOW! THE TOUGHEST

SHOT FIRING CABLE

EVER PRODUCED!

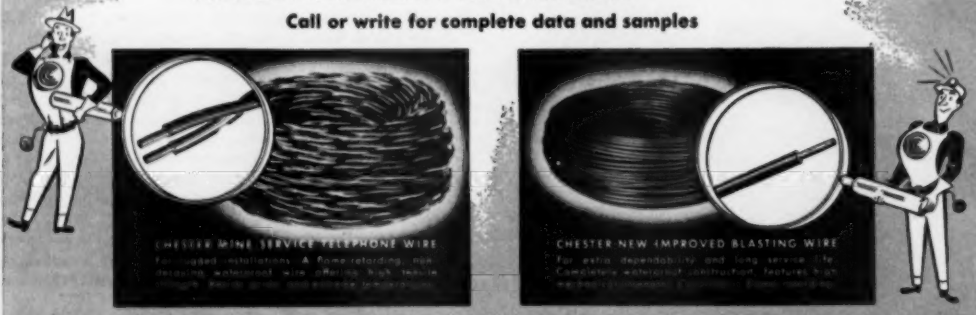
Check the long life qualities offered by this *SUPER DURABLE* SHOT FIRING CABLE

- RESISTS SHARP EDGES AND ABRASION
- FLAME RETARDING AND WATERPROOF
- NON-DECAYING AND NON-AGING
- HIGH STRENGTH AND FLEXIBILITY
- NON-CRACKING FROM −40°C to +80°C
- RESISTS MOST ALKALIS, ACIDS, OILS, GREASES
- IMMUNE TO OZONE AND SUNLIGHT

Exclusive CHESTER nylon jacket over center core increases service life and promotes mine safety

Here's the shot firing cable you can depend on for really tough mine service. It's highly durable when exposed to sunlight and ozone, withstands dragging over sharp edges and abrasives and is highly flexible. Non-cracking over a wide temperature range, Chester is flame retarding and waterproof—the kind of cable that's good for years of usefulness in all types of mining operations. Ask for Chester the next time you order — you'll agree, IT'S THE TOUGHEST SHOT FIRING CABLE EVER MADE!

Call or write for complete data and samples



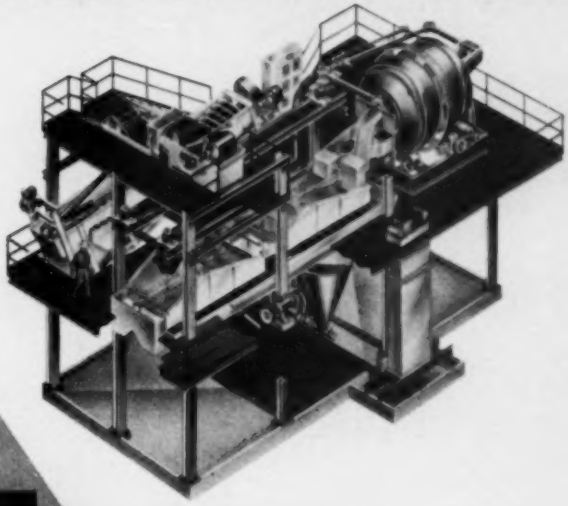
CHESTER CABLE CORP.
CHESTER, NEW YORK.

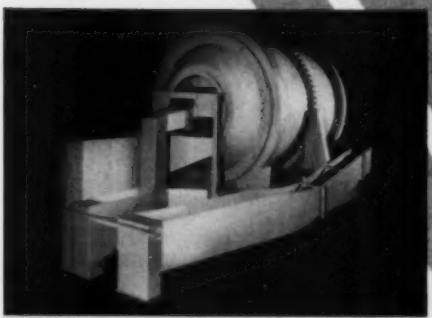
MANUFACTURERS OF QUALITY WIRES AND CABLES FOR EVERY INDUSTRIAL AND COMMERCIAL APPLICATION

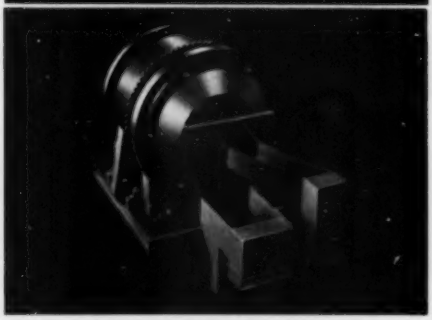
PRECISION CONTROL MEANS BETTER METALLURGY!

The WEMCO MOBIL-MILL gives you precise control of separating conditions with ores amenable to HMS.

WEMCO design allows accurate control of media density and positive sink removal—assures higher grade concentrate and lower tailings.







VERSATILE PERFORMANCE BOOSTS OPERATING PROFITS!

WEMCO MOBIL-MILLS give you **three** types of separators to choose from—fits the equipment to your problem for optimum operating efficiency:

1. **WEMCO** Double Drum Separator gives two stage separation in a single unit for treating ores having a middling component.
2. **WEMCO** Single Drum Separator gives positive sink removal and efficient control of media density for one stage separation over a wide range of size fractions.
3. **WEMCO** Cone Separator gives efficient, low cost separation on ores where a finer range of feed sizes requires greater volume of medium.

PREFABRICATION SPEEDS INSTALLATION, SIMPLIFIES OPERATION!

WEMCO MOBIL-MILLS are **prefabricated,** complete processing units manufactured to precise standards according to field-proven design. Mobil-Mills are quickly and easily installed by **your** mechanics or a **WEMCO** crew, are simple to operate and require a minimum of attendance.

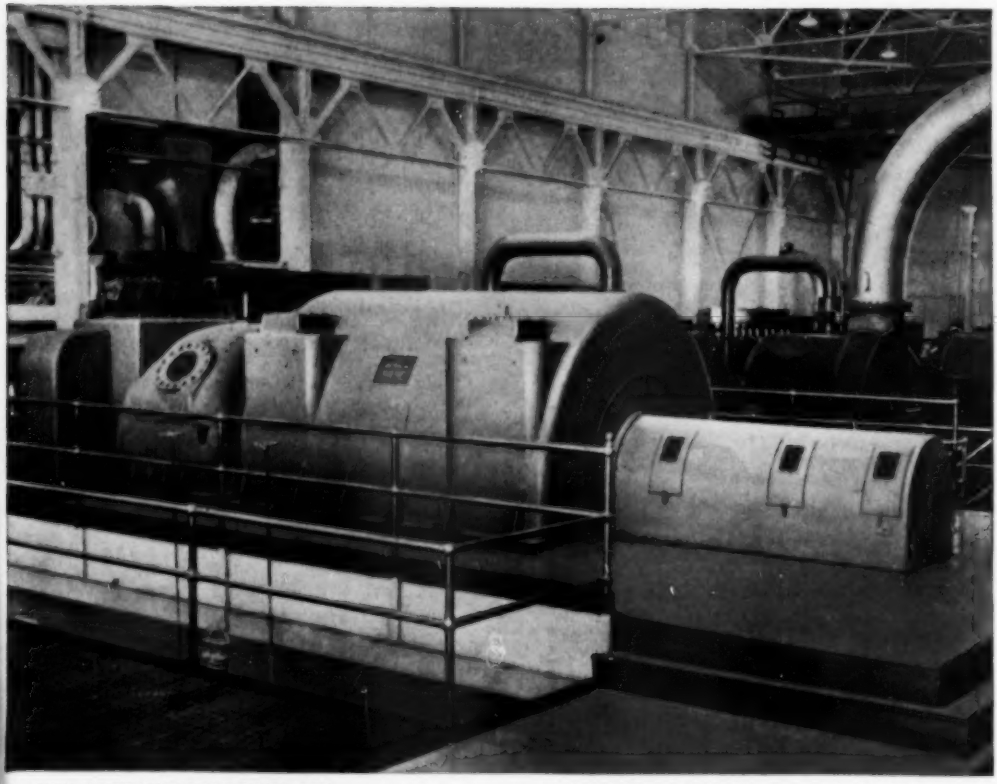
7 MOBIL-MILL ADVANTAGES

- *Prefabrication*
- *Low initial cost*
- *Clean, sharp separation*
- *Fast installation*
- *Compact design*
- *Low operating cost*
- *Capacities 5 to 275 TPH*

Write today for descriptive bulletin and information on how a Mobil-Mill can improve your beneficiation problem.

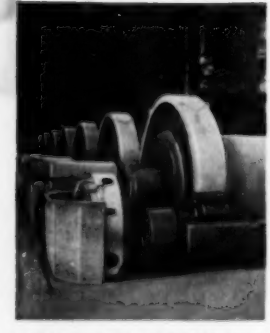
WEMCO
WESTERN MACHINERY COMPANY
700 FOLSOM STREET SAN FRANCISCO 7, CALIFORNIA

OTHER WEMCO PRODUCTS
Mobil-Mills • Coal Spirals • HMS Thickeners • HMS Pumps • Sand Pumps
Cone Separators • Drum Separators • Fagergren Laboratory Units • Agitators
Fagergren & Steffensen Flotation Machines • Hydroseparators • 6-N Classifiers
HMS Laboratory Units • Dewatering Spirals • Thickeners • Conditioners • Classifiers

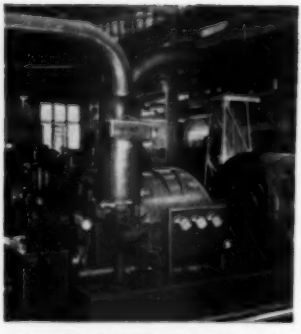


NEW G-E STEAM TURBINE-GENERATOR generates high-voltage power for this copper company's concentrating and smelting plant. Rated at 10,000 kw, 3600 rpm, the single-stage unit replaces an older 6000-kw unit which generated at 480 volts. Like every G-E turbine-generator, it is custom-built from standard components to meet specific operating conditions.

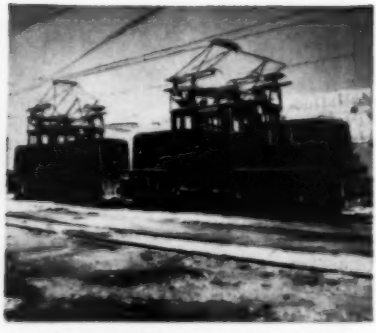
Power system modernized for



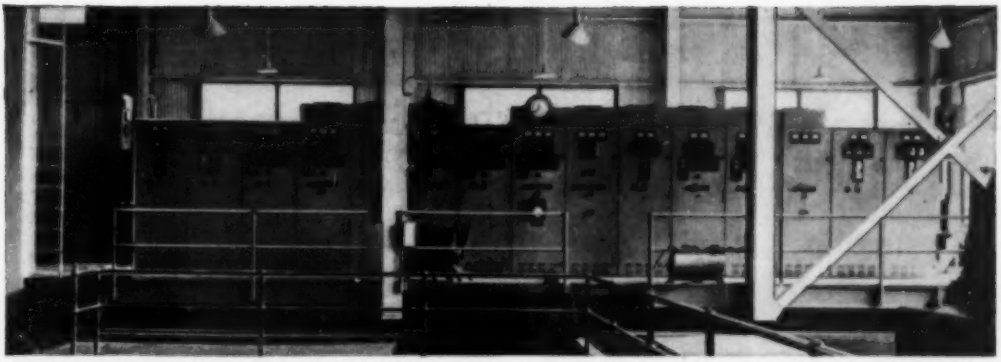
POWER-FACTOR IMPROVEMENT is provided by 28 200-hp synchronous motors driving plant's ball mills.



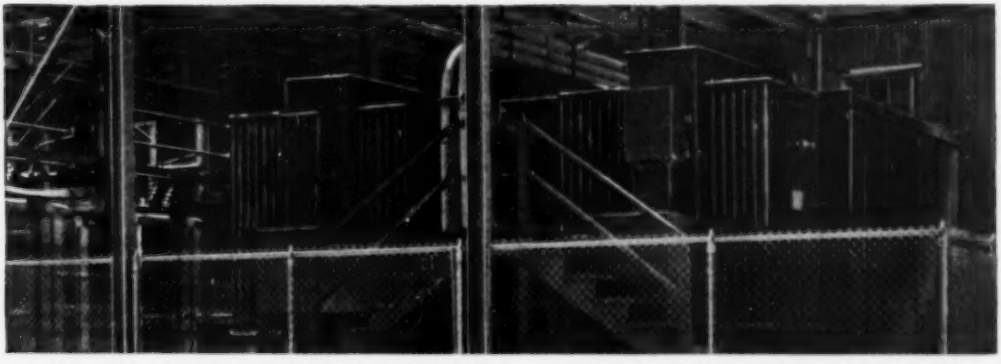
MECHANICAL POWER to drive two turboblowers is generated from process steam by 1915-hp G-E mechanical-drive turbines.



LOW-COST HAULAGE from the copper plant's open pit mine 15 miles away is provided by these two G-E 750-volt 85-ton electric locomotives.



2 **NEW G-E METAL-CLAD SWITCHGEAR** distributes high-voltage power to load-center substations in electrical load areas. These co-ordinated units are shipped completely assembled and ready for installation. Their compact design saves floor space.



3 **NEW G-E LOAD-CENTER SUBSTATIONS,** completely metal-enclosed, step down power from primary voltage to 480-v for use in the ball mill area. High voltage power distribution to load centers reduces voltage drop and cuts power losses.

more efficient distribution

Copper plant increases capacity by adding G-E turbine, switchgear and load-center substations to existing power system

As part of a continuing modernization program at its concentrating and smelting plant, a large copper company in the Southwest recently installed new General Electric high-voltage power generation and distribution equipment. With these new facilities, power is generated and distributed the modern, high-voltage way. Result: increased protection against shutdowns, lower power-distribution cost.

You, too, can benefit from the kind of G-E application engineering that went into this installation. Call your nearest G-E office and ask for a mining specialist. *General Electric Company, Schenectady 5, New York.* 660-25

Engineered electric systems for the copper industry

GENERAL ELECTRIC

get FULL VALUE loading...

choose GARDNER-DENVER Mine Car Loaders

a FULL *dipper every bite . . .*

because two high torque air motors function together on the powerful crowding action—and the Gardner-Denver moving fulcrum provides extra force for digging into stubborn muck piles.

FULL *to the top mine car loads . . .*

Extra speed developed by the moving fulcrum as the dipper nears discharge position throws the ore far back to completely fill your big capacity mine cars.

FULL *time availability . . .*

Heavy-duty construction, fewer moving parts and protected lubrication keep Gardner-Denver Mine Car Loaders underground—enable you to plan on using your Gardner-Denver Loader 'round the clock, at several different faces.

FULL *measure of safety . . .*

Low center of gravity, clean exterior design, simple and convenient controls and other safety features protect your miners against injury.

Send today for Bulletin MCL.

Gardner-Denver Loader quickly cleans up a round of coarse, abrasive muck.

The smaller GD9 Mine Car Loader—for fast loading in low or narrow headings.

The GD14 "Big Bite" Loader—for high tonnage loading into big mine cars.

SINCE 1859 **GARDNER-DENVER**

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., Toronto, Ontario

THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS

Dry Rolling Toggle

with Rockin' Chair Motion

A-1 Jaw Crushers

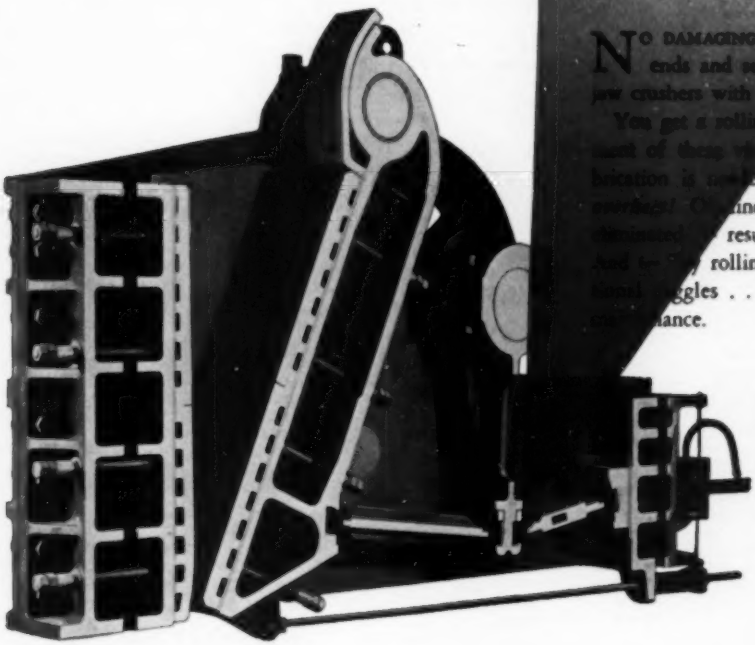
Reduces Maintenance and Downtime

No Lubrication Needed

NO DAMAGING sliding action of toggle ends and seats when you equip your jaw crushers with dry rolling toggles!

You get a rolling "rocking chair" movement of these moving parts. No lubrication is needed, yet toggle ends *never* overheat! Oil lines and messy oil drip are eliminated, resulting in increased safety. And dry rolling toggles outlast conventional toggles . . . operate with reduced maintenance.

A-3738



You can easily make your jaw crusher operations *more profitable* with dry rolling toggles. Call the A-C representative in your area, or write Allis-Chalmers, Milwaukee 1, Wis.

A-1 is an Allis-Chalmers trademark.

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A-C ALLIS-CHALMERS

Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

Hammermills

Vibrating Screens

Jaw Crushers

Gyratory Crushers

Grinding Mills

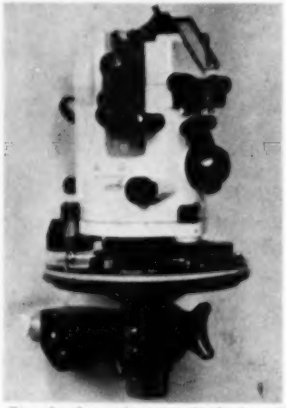
Kilns, Coolers, Dryers

Manufacturers News

New Products • FILL OUT THE COUPON FOR MORE INFORMATION • Equipment

Transit

A light weight, totally enclosed theodolite, especially designed for mining, has been placed on the market by *Askania Werke, A. G.* The instrument weighs only 4¼ lb and measures 5⅛ x 7⅛ in. without tripod and in a waterproof aluminum hood. It may be mounted on tripod or bracket without removing the protective hood.



Standard equipment includes diagonal eyepiece rotating in all directions which eliminates need to be in line with scope for sighting and makes an auxiliary scope unnecessary for steep sights. The transit reads direct to 1 minute and may be estimated to 6 seconds by means of optical micrometer on both horizontal and vertical circles. The telescope in vertical position serves as optical plummet, sighting through an opening in the base.

The instrument is shown above mounted for attaching to a pin driven in timber or rock, eliminating tripod or set-up bar in cramped quarters. The chain clamp in the lower picture is used on timber or steel ground supports. Complete with carrying case and set-up brackets, ready for use in a raise, it weighs less than 6 lb, and the protective hood remains on until the instrument is securely mounted.

Accessories for increasing versatility of this mining theodolite are: tripod, electric illumination for optical micrometer and reticule, close range objective lens, and objective lens prism for sighting vertically in front of the instrument. **Circle No. 1**

Centrifugal Compressor

A centrifugal compressor developed by the *Sawyer-Baily Corp.*, for handling gases at 600 psi and higher, is said to operate efficiently at flows as low as 125 cfm. Being of centrifugal type it will handle gases having high content of abrasive solids and is particularly adapted to fluidizing granular material. These compressors are said to be smaller than reciprocating compressors of corresponding capacity and feature simplicity of construction. **Circle No. 2**

Lighter-Tip Cleaner

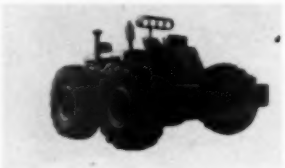
A three flint spark lighter and tip cleaner in one tool, marketed by *Thermacote Co.*, has a case of 12 spiral tip cleaners attached to the handle of the heavy-duty three flint spark lighter. **Circle No. 3**

Drill Steel

Following their line of chisel-type Intra-Set drill steel, in which steel and carbide bit are integral, the *Rock Bit Sales and Service Co.* now offers four-point Intra-Set steel, made in 1⅛ in. to 2¼ in. gauge sizes and in lengths up to 12 ft with shanks for any hammer. **Circle No. 4**

Pusher Unit

The Tournatractor, built by *R. G. LeTourneau, Inc.*, is a new pusher unit. The pusher is the Super C Tournadozer with a billet and pusher plate in place of dozer blade and



controls. It is also adaptable to pulling operations. Dozer conversion blade and controls may be added later. **Circle No. 5**

Heated Screen

The new FlexElex electric screen heating device, used on the Leahy No-Blind vibrating screen, produced by the *Deister Concentrator Co.*, is especially designed for fine mesh screening of damp materials, such as clays, shales, fine coals, pulverized limestone, or sticky ores. Low voltage, high amperage electric current is passed through the screen cloth, heating the wires sufficiently to keep them clean. Elimination of screen cloth cleaning offers economies claimed to more than offset power cost of heating the screen, and opens a new range of economic screening applications. **Circle No. 6**

Backsight

Claimed to be visible for more than 1000 ft from any angle is an illuminated underground surveyors backsight, available from the *Plastic Shop*. Self-powered, the sight is made in two and three-cell sizes. **Circle No. 7**

Vibrator

The Ozark Ore Co. is using Cleveland Type F air vibrators to help move stuck materials. They have installed 24 *Cleveland Vibrator Co.* units on Pan-American iron ore jigs to vibrate the hoods over spigot discharges. **Circle No. 8**

Packing

Extruded Teflon plastic packing, designed for difficult applications has been introduced by *Flexrock Co.* It has been proven for use in centrifugal pumps handling caustics, and other hard-to-handle solvents. **Circle No. 9**

Shelving

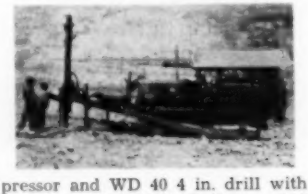
Super-strong shelving, part of the complete Iron-Grip line announced by *Equipto Division, Aurora Equipment Co.*, is designed to carry up to a ton per shelf. A special stud speeds assembly, and no nuts, bolts, or tools are needed for shelf adjustment. Dividers, backs and sides are available in all sizes. **Circle No. 10**

Zircon Sand

Foundry grade zircon sand is available in carload lots according to *Foote Mineral Co.* Advantages claimed for this sand are superior surface smoothness, greater casting accuracy and lowered cleaning costs. Zircon sand also has a high rate of heat diffusion, which minimizes shrinkage stresses. **Circle No. 11**

Uni-Drill

New unit for rock contractors and open pit miners is available from the *Worthington Corp.* The Uni-Drill incorporates a V-belt driven com-



pressor and WD 40 4 in. drill with 12 ft steel chain feed, both mounted on a tractor. Major savings in moving and set-up time are claimed, total time varying from two to six minutes. A cable unit raises the "D" frame, with chain feed and drill attached, when moving. **Circle No. 12**

Free Literature

BIG REELS OR SMALL can help meet the shortage. Return all your "empties" and you'll get faster deliveries from your manufacturer on new orders.

(13) CONTROL: Combined use of punched-card tabulating equipment, Sched-U-Graph, and Kardex units for production control and payroll systems is the subject of a new Narrator released by *Remington Rand Inc.*

(14) CHAIN: A bulletin by *Acmor Conveyor Chain Co.* describes standardized attachments which permit time saving by quick assembly from stock chain and parts.

(15) MECHANIZATION: A visual program aimed at boosting productivity, announced by *General Electric Co.*, "Progressive Mechanization" presents a consolidation of the principles of production that have made our nation the leading force in world economy. The program, 24th in G E's More Power to America series consists of three parts: sound-color film, manual, and survey form and checklist. More information on the program may be obtained from the manual, which is now available.

(16) ELECTRICAL: The *Joy Manufacturing Co.* has just published a new two-color eight page bulletin providing order numbers on five different families of electrical connectors, giving data on safety-circuit power distribution, cable vulcanizers, electric track switch throwers and String-a-lite portable lighting assemblies.

(17) SCALES: Condensed catalog No. 11 from the *Howe Scale Co.* covers a line of weighing equipment ranging from standard platform types to automatic Weightograph units.

(18) HOSE: Specific data on industrial rubber hose assemblies for mining equipment are listed by *Carlyle Rubber Co.* in a new catalog.

(19) MOLY-SULFIDE: As producers of molybdenum disulfide for lubrication *Climax Molybdenum Co.* have prepared: "Moly-sulfide, a little does a lot."

(20) DIAMONDS: Articles and patents published during 1951 that have a special bearing on industrial diamonds are covered in a brochure from *Industrial Diamond Information Bureau.*

(21) d-i CELL: The Dorrco d-i cell, developed to meet the exacting requirements for ion-exchange in the process industries is described briefly in a leaflet from *The Dorr Co.* This cell has two design features of importance, a level control and air dome system, and a special underdrain assembly.

(22) DEHUMIDIFICATION: Moisture measurement and removal are the topics of a bulletin from *Abbeon Supply Co.*

(23) TROLLEYPHONES: "Your Voice of Action" is the title of a newly released brochure describing the Femco Trolleyphone plug-in model. This model is more compact and easier to install and service. Power is taken directly from trolley wire or power line. *Farmers Engineering and Mfg. Co.*

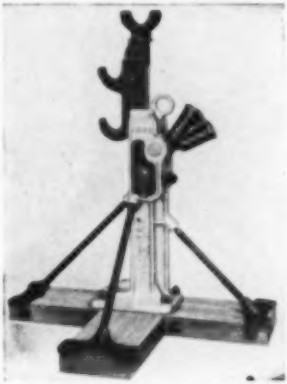
(24) BATTELLE INSTITUTE: We have received two interesting publications of the *Battelle Memorial Institute*, entitled "Research in Engineering Economics" and "Research in Production Engineering." These bulletins describe available facilities at the Institute and show how Battelle serves industry.

(25) COAL CLEANING: A booklet entitled "The Evolution of Cleaning Coal with Dense Media," was written to serve as an informative paper for coal operators by the *Nelson L. Davis Co.* The booklet sets forth the various problems encountered and their solution.

(26) CRUSHERS: Do you know how to select a crusher? To assist "the man who, sometime may want to select a crusher," the *Pennsylvania Crusher Co.* has prepared a handbook that explains in a simple manner crushing methods and where they apply in practice.

(27) CUTTERS: A *Manco Mfg. Co.* two-color, 8-page catalog on their Guillotine portable hydraulic cutting tools also lists a complete line of special and accessory equipment.

(28) JACKS: Cable reel jacks from 20 to 90 in. diameter in capacities of



5, 10 and 15 tons are featured in a two-page bulletin published by the *Duff-Norton Manufacturing Co.*

(29) SCRAPERS: Heavy equipment men in construction and mining will be interested in a booklet on scrapers from *Caterpillar Tractor Co.* Specifications cover scrapers up to the 27 cu yd capacity No. 90.

Mining Engineering **August**
29 West 39th St.
New York 18, N. Y.

Please send me { More Information ☐ / Free Literature ☐ / Price Data ☐ } on items indicated.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30

Students are requested to write direct to the manufacturer.

Name_____ Title_____

Company_____

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Sulphur

Molten Sulphur flowing into the storage vat

Thousands of tons mined daily, but where does it all go?

Look around you in any grocery store and what do you see — canned goods of all kinds! Soups, vegetables, fruits, berries! Believe it or not, you're looking at merchandise that consumed a lot of Sulphur in the making.

Tin cans are made of tin plate. Tin plate is made of sheet steel. Sheet steel is made with the help of sulphuric acid—pickling, as they call it, the process that removes scale preparatory to plating. In 1951, the sheet division of our great iron and steel industry is estimated to have consumed 140,000 long tons of Sulphur in the form of sulphuric acid. That in itself makes quite a dent in our supplies of Sulphur. Add to this almost as much more for treating wire rod, plate, strip, bars, etc., and you can see that to make finished steel, regardless of form, the iron and steel industry must use lots of Sulphur in the form of sulphuric acid.

Right here is an excellent example of the interdependence of all of our industries. To produce steel requires a lot of Sulphur. To produce Sulphur and other mined products requires a lot of steel. This interdependence of industries is one of the country's sources of strength.

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Modern Metal Mine Haulage Calls for Modern Methods like this

JEFFREY SHUTTLE CAR

Above—a Jeffrey 42-inch high Cable Reel Shuttle Car operating in a prominent lead mine, hauling ore from working place to main haulage system. An outlined view of this Car is shown left—below.

Jeffrey Shuttle Cars, operating in the coal fields, have come closer to continuous production than any other system developed to date. Rock-handling Shuttle Cars are applicable to many metal and non-metal operations—will provide efficient and dependable service in the handling of ores.

This method of haulage has advantages of flexibility, mobility, quick loading and discharging—which make for large tonnages and low-cost operation. They are available in cable reel types.

Call in a Jeffrey Mining Engineer—let him help you determine the equipment best suited to your operation.

JEFFREY

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1877 75 1952

MEET THE AUTHORS

T. M. Morris *(Measurement and Evaluation of the Rate of Flotation as a Function of Particle Size, P. 794)*, was the commanding officer of a patrol craft charged with guarding Aleutian waters against infiltration by the Japanese during World War II. Before going into service, he was an assistant research engineer with Anaconda Copper at Anaconda, Mont., and later a metallurgist with Tennessee Copper Co. Presently he is a professor in the Department of Metallurgy, Missouri School of Mines, Rolla, Mo. A member of the AIME, he is a graduate of Columbia University and the University of Missouri, with a Bachelor of Science, Master of Science and a Ph.D. Professor Morris is the author of a previous paper for the AIME, *Measurement of the Equilibrium Forces Between an Air Bubble and an Attached Solid in Water*. An outdoor man by predilection, he enjoys bird watching and hiking in his free time.

W. R. Hudspeth *(Spirals Recover Heavy Mineral By-Product, P. 767)*, Foote Mineral Co., metallurgist at Kings Mountain, N. C., was the co-author of a previous paper, *A New Method for Recovery of Flake Mica*, presented at the 1950 Annual Meeting in New York. He has a bachelor's degree from Wake Forest College, and did graduate work at University of Wisconsin and University of North Carolina. Before going to Foote Mineral, Mr. Hudspeth was employed as an ore dressing engineer with Asheville Minerals Research Laboratory. He is also assistant mill superintendent at Kings Mountain. He is a member of the AIME and sports minded. Mr. Hudspeth lists golf and hunting and fishing as his main hobbies.

W. R. HUDSPETH

WILLIAM R. WEBB

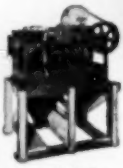
William R. Webb *(Maintenance and Training Pay Safety Dividends at Benson Mines, P. 768)* is manager of the New York Ore Division of Jones & Laughlin Steel Corp. Mr. Webb started with J & L as a metallurgical inspector, and advanced to production superintendent of the Blair Limestone Division, before taking over his present assignment. He submitted one other paper to the AIME, *An Experimental Open Hearth*. After matriculating from Taylor Alldercise High School, Mr. Webb went on to La Fayette College. He now lives at Star Lake, New York, scene of J & L's New York Ore Division operations. Mr. Webb claims ore mining as his hobby, but when the opportunity presents itself, he takes rod and reel or shotgun in hand and goes into the field.

Denver-Dillon Vibrating Screens

Denver Ore Feeders

Denver Steel-Head Ball Mills

Denver Disc Filters



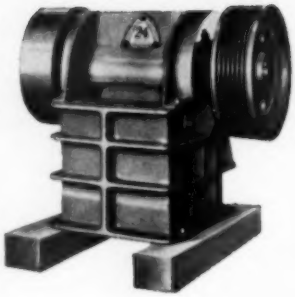
Denver Selective Mineral Jigs

DENVER FORCED FEED Jaw Crushers

Sizes:

(Type "H"—anti-friction bumper bearings, bronze side bearings.)

2¼" x 3½"	8" x 10"
3¼" x 4½"	10" x 16"
5" x 6"	10" x 20"



Denver SRL Pumps

Sizes:

(Type "F"—anti-friction bearing crusher.)

10" x 24"	18" x 36"
10" x 36"	21" x 36"
15" x 24"	21" x 40"
15" x 36"	25" x 40"
18" x 24"	32" x 40"

Denver-Buckman Concentrators

Specifications: Cast steel or fabricated steel frame. Cast steel bumper. 13%-14% Manganese steel jaws and cheek plates. Forced Feed crushing action. Safety toggle of cast iron protects against tramp iron.

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MEET THE AUTHORS Cont'd

WILLIAM T. TURRALL

G. C. Lipsey *(The Development of a Mining Operation From Diamond Drill Data, P. 784)* began his career in 1924, becoming an engineer shift boss, foreman and superintendent, successively, with the Britannia Mining and Smelting Co., Ltd. In 1937 he went to Howe Sound Co., Holden, Wash., and served as general superintendent until 1939. From 1939 to 1945 Mr. Lipsey was employed by B. M. & S. Co., Ltd., as mine superintendent. He is now General manager of Howe Sound Exploration Co., Ltd., at Snow Lake, Man. A graduate of the University of British Columbia, Mr. Lipsey also holds a Bachelor of Science in Mining and is a member of the AIME. He is a sports enthusiast but favors contract bridge as his chief diversion.

G. C. LIPSEY

C. O. Lee *(Development and Operation of Sulphur Deposits in the Louisiana Marshes, P. 775)* has been employed by Freeport Sulphur Co. from 1926 to the present. Today, he is the Assistant General Manager of the organization, living in New Orleans. Mr. Lee received an E.M. Degree from the University of Minnesota School of Mines, and is a member of the AIME. When he can take the time, he likes to get in 18 holes of golf.

Editor's note: The author of the July MINING ENGINEERING Article, *A Survey of Latin American Mining Law* is Edwin M. Weiss, and not Edward M. Weiss, as incorrectly bylined.

William T. Turrall *(Photoelectric Sorting of Optical Fluorspar, P. 803)* was awarded a Bachelor's in mining at the University of Toronto, followed by a Master of Science degree. An AIME member, this is his first paper published by the Institute. He has been, in succession, assistant mill superintendent of McIntyre Porcupine Mines, Schumacher, Ont., paymaster, Consolidated Gold Mines, South Porcupine; lecturer, ore dressing, Dept. of Mines, University of Toronto; engineer in charge, industrial mineral beneficiation, Bureau of Mines, Ottawa, Ont., and in consolidation with Metallic Mineral Div., Assistant engineer in charge of all mineral beneficiation; assistant professor, Dept. of Metallurgy, M.I.T.; superintendent of preparation, Lehigh Navigation Coal Co., and consultant on mineral engineering, Lehigh Navigation. He is presently with Lehigh, living in Lansford, Pa. Mr. Turrall turns to the surf for his amusement being an amateur sailor and competitor in sailing races.

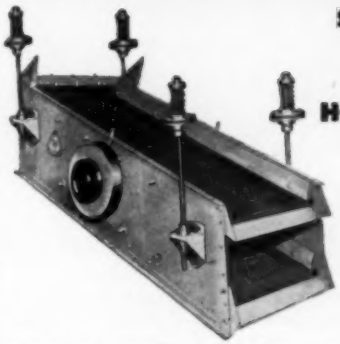
Denver "Sub-A" Flotation

Denver Cross-Flow Classifiers

Denver Hydroclassifiers

Denver Super-Agitator and Conditioners

DENVER-DILLON Vibrating Screens



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Denver Reagent Feeders

Denver Pulp Distributor

Denver Thickeners

Denver Jaw Crushers

Notice, on Denver-Dillon Vibrating Screens, that bearings are not anchored to heavy channel iron or other supports. Weight of screen and load is suspended. Bearings support only weight of flywheels and shaft. Screen is free of restrictions to impart maximum vibration to entire screen body.

You save on initial cost, too, for this patented action eliminates unnecessary weight and fabricating costs.

Please write to us about your requirements. Quantity production of standard equipment means lower cost and good deliveries • Complete mill equipment from testing to feeder to dryer.

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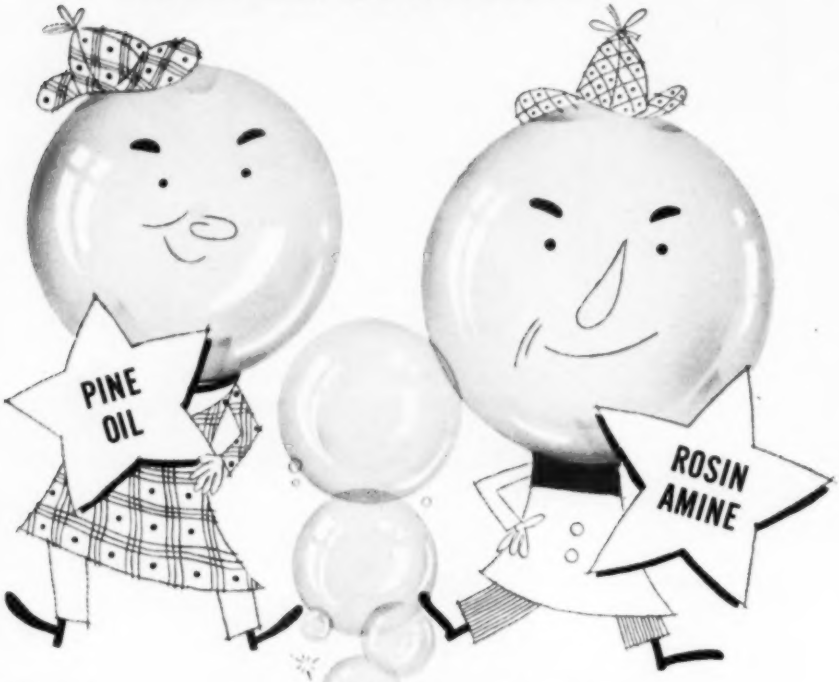

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Standard of quality among pine oil frothers since the early days of flotation. Yarmor F Pine Oil produces a strong froth of good volume, satisfactory texture, and excellent cell-life stability.

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RADA (Hercules Rosin Amine D Acetate)
Siliceous mineral collector that has good solubility and handles easily.

Rosin Amine Derivatives: Special purpose collectors; uses vary with type of materials to be floated.

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NM52-1

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Massive, muscular structure gives the elephant the overpowering strength he needs to ward off the attacks of predatory enemies. Even in a hostile environment, these huge animals may stretch out their life span to well over a hundred years.

In wire rope, too, prolonged life is dependent on specialized muscles that will give best resistance to the destructive forces encountered... whether they be abrasion, bending fatigue, load strain or shock stress. That is why in Wickwire Rope we make sure that you get the right grade of steel and size of wire... the right construction and lay of the rope... in short, the right kind of muscle for your particular job.

For full information contact our nearest sales office.

THE COLORADO FUEL AND IRON CORPORATION—Abilene (Tex.) • Denver • Houston • Odessa (Tex.) • Phoenix • Salt Lake City • Tulsa
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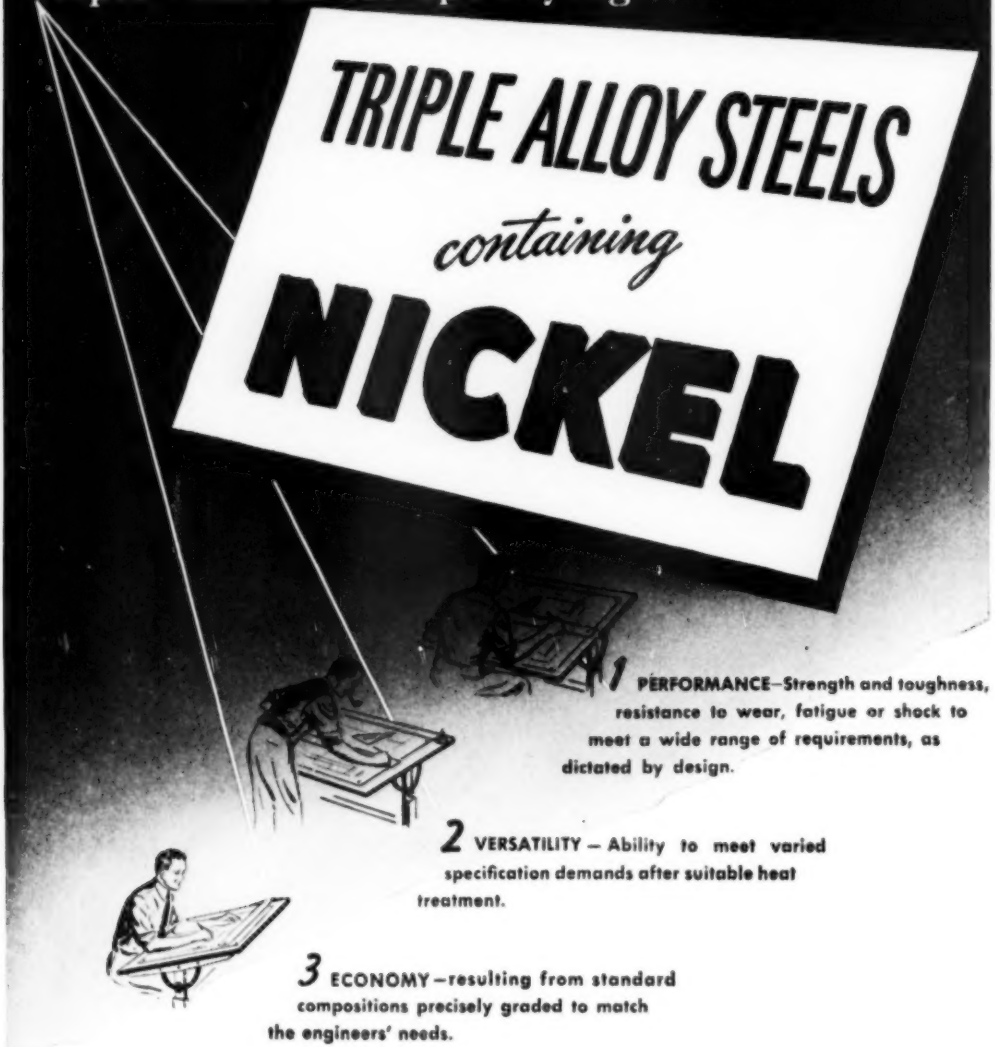
TRIPLE ALLOY STEELS *containing* NICKEL



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2 VERSATILITY – Ability to meet varied specification demands after suitable heat treatment.

3 ECONOMY—resulting from standard compositions precisely graded to match the engineers' needs.

Experience shows that triple-alloy steels containing Nickel are solving some mighty big problems in many industrial fields. They have established outstanding service records in some of the most exacting applications. The many standard compositions available make it possible to select *accurately*, and with economy, triple-alloy steels to fulfill the requirements of a great variety of applications.

We invite inquiries regarding the selection and uses of triple-alloy steels, containing Nickel.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

Noranda Mines, of Quebec, signed a contract for construction of a $20 million copper refinery at Gaspe, P.Q. The plant is expected to have a 6500-ton daily capacity for both concentrator and smelter. Extensive drilling around Gaspe has revealed more than 65 million tons of 1 to 2 pct copper in several deposits.

Cerro de Pasco Corp., has called a special stockholders meeting for August 19 to obtain permission to engage in the oil and natural gas business, in addition to its present production of zinc, lead, copper, silver and other metals. St. Joseph Lead Co. recently entered the oil development field.

The United States, Canada and Great Britain have agreed to establish a permanent organization to work on unification of engineering standards. General accord has been reached on drafting standards and practices, screw threads, fittings for gas cylinders, and fits and tolerances. Permanent committees will study these fields.

Reconstruction Finance Corp. approved the largest sum in its history for a mining enterprise when it loaned $94 million to San Manuel Copper Corp., of Pinal County, Ariz. The loan will be used to increase production of copper and molybdenum, in what was described as the biggest copper deposits in the country.

Three large gold mining concerns operating in the Philippines told the Philippine Wage Board that they would be forced to close if they had to boost miners' wages 50¢ to $2 per day. The companies are Mindanao Mother Lodes, Benguet Consolidated, and Balatoc Mining Co.

Aluminum Co. of Canada will supply Aluminum Co. of America with 8.7 million lb of aluminum to help make up the loss suffered by the U. S. firm when its Messena, N. Y. plant suffered storm damages. The shipment is being made at the request of the U. S. Government.

Defense Materials Procurement Agency has signed a contract obligating the Government to buy 50 million lb of molybdenum to be produced from low grade ores. The contract is with Climax Molybdenum Co., and calls for mining ores so situated in the company's mountain property around Lake County, Colo., as to be unmineable without Government assistance.

U. S. Steel Co. has been granted a fast tax-write-off on 65 pct of $99 million worth of iron ore transportation facilities planned for its Ciudad Bolivar ore deposits on the Orinoco River in Venezuela.

The U. S. Government is entering into a nationwide program for buying carload lots of manganese ore and concentrates from small domestic producers for resale to industry. The program is scheduled to run until June 30, 1956 or until deliveries total 19 million long dry ton units of manganese.

The compact design of CP ROTORdrifters — with rotary feed motor built into the drill between backhead and drifter cylinder — makes them particularly suitable for close-quarter operations.

CP MOTORdrifters — with feed motor on the end of the shell — are specifically designed for the longer feeds sometimes preferred in large bore tunnels.

Every type of ROCK DRILL

for modern mining

Designed both for blast hole and exploratory drilling, the air-driven CP No. 55 DIAMOND CORE DRILL has the most powerful vane-type air motor ever built into a diamond drill. Conservatively rated at 500 feet with E Rods and EX Fittings.

CP-34 STOPERS have all the features that assure maximum footage from tungsten-carbide bits. The combination of strong rotation, fast hitting action, and the right foot-pound blow give maximum penetration and long bit life. Medium weight, fully cushioned piston and fine running balance make the CP-34 easy to handle. Constant air blow keeps all sludge out of the drill.

For the toughest drilling jobs, the heavier CP-44 STOPERS are recommended.

The complete line of CP SINKER DRILLS, ranging from the CP-22 (28-pound) to the CP-50N (102-pound), includes the CP-32, a top performer in the 45-pound class, and the CP-59, leader in the 55-pound class. Both of these can be furnished with the CP AIRLEG, which provides a rigid, well-balanced support and effectively absorbs all recoil.

Designed for maximum speed and efficiency in tunnel driving, the rail-mounted G-600 AIR ACTUATED DRILL JUMBO is furnished in single and multi-boom units.

OTHER CP MINING EQUIPMENT

Exploratory Diamond Drills, gasoline, air and electric powered . . . Wagon Drills . . . Sludge Pumps . . . Sump Pumps . . . Pneumatic Impact Wrenches . . . Stationary and Portable Compressors . . . Pneumatic and Electric Construction and Maintenance Tools.

See CP Mining Equipment at the Mining Show

BOOTHS 510 and 514

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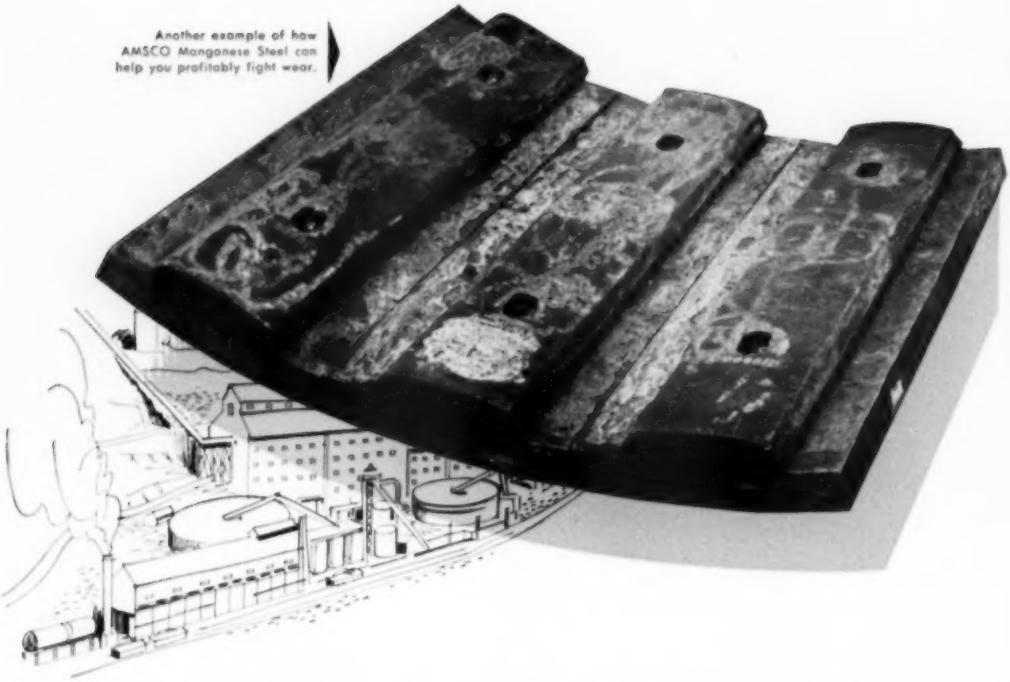

These LINERS lasted 6 times longer

How AMSCO Manganese Steel increased production . . . lowered costs per ton

A large Western mine had a problem that's all too common . . . Rod Mill Liners that lasted approximately 100,000 tons before an expensive replacement job was necessary.

In July of 1949 something new was tried. This mine installed AMSCO Liners equipped with a specially designed renewable lifter. Result? The AMSCO Liners milled 640,208 tons . . . over 6 times the tonnage of the liners formerly used. There were two important reasons for this tremendous increase in service life:

1. The liners were made of AMSCO Manganese Steel, the toughest steel known for high resistance to abrasion and impact.

2. The overlapping type AMSCO Renewable Lifters took the brunt of the load—reduced the need for replacing the more expensive liners. The lifters alone milled 340,322 tons . . . over 3 times more than the old installation!

WHEREVER YOU MEET A PROBLEM OF WEAR CAUSED BY IMPACT AND/OR ABRASION . . .

. . . find out about longer-lasting, dollar saving Manganese Steel made by AMSCO . . . world's largest producer of Manganese Steel Castings for all industry.

AMSCO controls impact and abrasive wear in 5 basic industrial operations:

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Mining and Excavating

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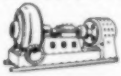
Materials Handling

AMERICAN Brake Shoe COMPANY

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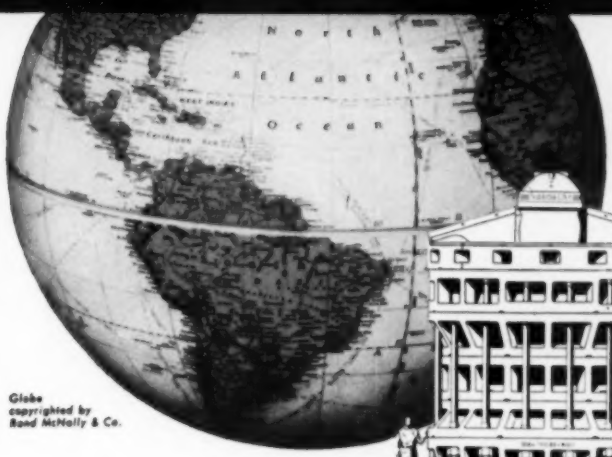
Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
Amsco Welding Products distributed in Canada by Canadian Liquid Air Co., Ltd.

WHEREVER MINERALS ARE PROCESSED...



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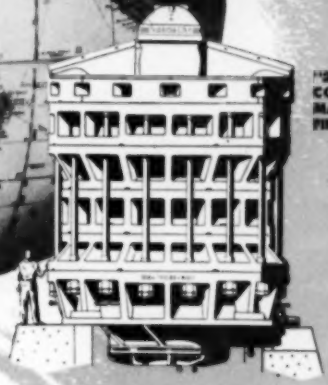
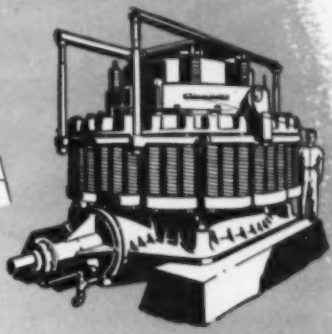
for BASE and PRECIOUS METALS ... the RARER ELEMENTS ... METALLIC and NON-METALLIC MINERALS

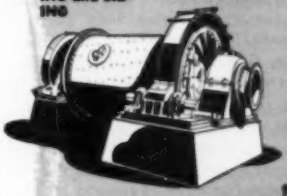


"SYMONS" GYRATORY and CONE-CRUSHERS for PRIMARY, SECONDARY and FINE REDUCTION CRUSHING

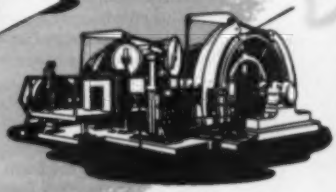


"SYMONS" VIBRATING GRIZZLIES and SCREENS for SCALPING and SIZING

"SYMONS" "V" (VERTICAL) SCREENS for EXTREMELY FINE SEPARATION



BALL, TUBE and ROD MILLS for WET and DRY GRINDING



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It is highly significant that wherever mineral resources are found in quantity—efficiency minded producers are now using, or are in the process of installing, Nordberg Machinery.

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NORDBERG MFG. CO., Milwaukee, Wis.

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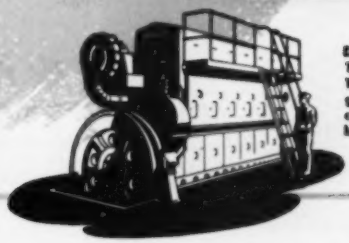

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CARLON is the only pipe that is guaranteed against rot, rust and electrolytic corrosion. It features absolute resistance to the chemical attack of sulphurous waters, alkalies, and metallic salts. Permanent free-flow is assured by the smooth internal surface which will not accumulate scale or sediment.

CARLON plastic pipe is lightweight . . . flexible . . . can be installed quickly without special tools or rigging equipment. Furnished in long lengths which conform to irregular surface contours, it requires fewer fittings.

Recommended applications include drinking water and drainage systems, ventilating lines, hydraulic sluicing, intake and exhaust piping, dredge discharge lines, low-pressure air lines, etc.

NOM. SIZE	O.D.	I.D.	EST. BURST P.S.I.	WT. LBS. PER FT.	SHPG. LENGTHS
½"	0.840	0.622	540	0.103	400 ft. coils
¾"	1.050	0.824	350	0.140	400 ft. coils
1"	1.310	1.070	200	0.181	300 ft. coils
1¼"	1.660	1.380	200	0.267	300 ft. coils
1½"	1.900	1.610	200	0.320	250 ft. coils
2"	2.378	2.070	170	0.445	200 ft. coils
2½"	2.875	2.469	170	0.680	200 ft. coils
3"	3.504	3.070	165	0.910	100 ft. coils
4"	4.504	4.030	150	1.250	25 ft. str.
6"	6.630	6.070	115	2.230	25 ft. str.

Identification Stripe: **WHITE**—Standard Pipe
RED—Heavy-duty Pipe

CARLON CP 160-CP

Specify the Pipe with the Stripe!

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For livelier froth— use DOWFROTH 250

To its desirable characteristics of better frothing, better metallurgy and water solubility, Dowfroth 250 adds economy. In actual mill tests, concentrations *as low as one-fourth of normal concentrations* have proved satisfactory! Use this new frother for a froth that's livelier on the machine, quicker breaking in the launders and pump boxes—write to Dow, Dept. OC 27, for your free sample.

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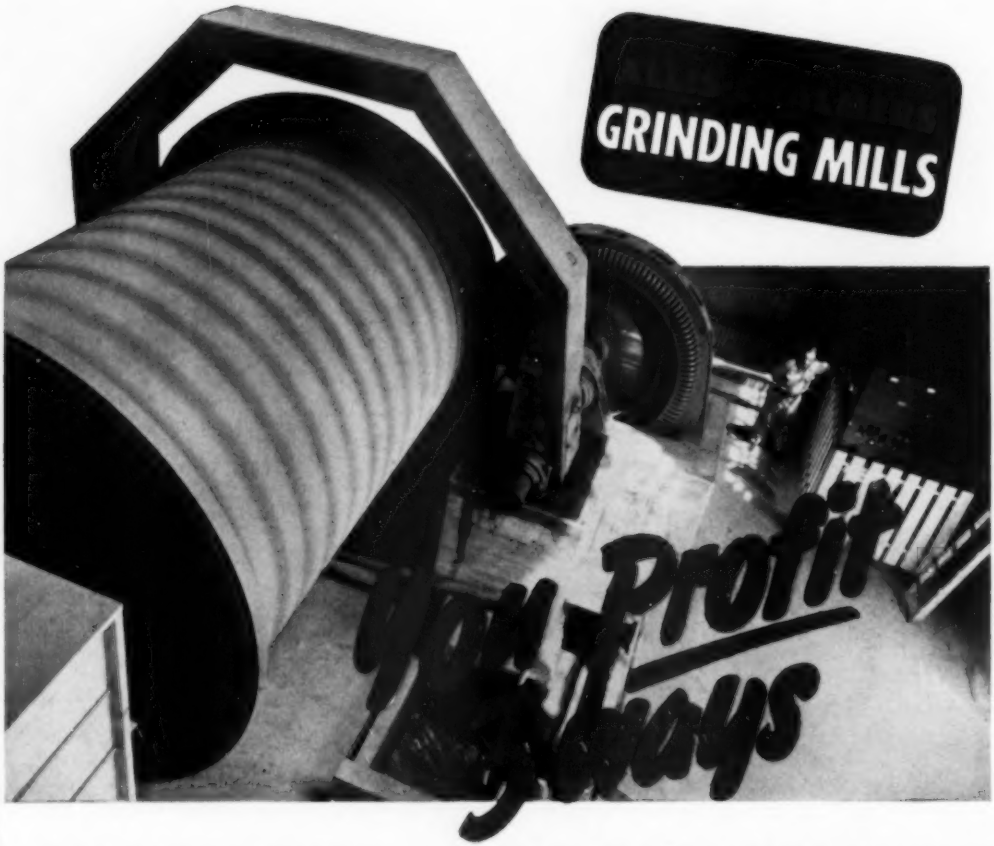
CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE



...WHEN YOU SPECIFY ALLIS-CHALMERS GRINDING MILLS

1 **YOU CAN BE SURE** of getting a grinding mill specifically suited to your requirements. A wide range and multiple combinations of types and sizes assures this . . . assures top, economical performance year in, year out.

2 **YOU GAIN** the seasoned benefits and *unequalled* experience accumulated through the successful installation of more than 4200 Allis-Chalmers mills over a period of 70 years.

3 **YOU ARE DOUBLY ASSURED** of completely balanced operation, with its resulting economies, when you equip your mills with motors, drives and controls — all manufactured in A-C shops.

Pulverator is an Allis-Chalmers **trademark.**

NEW 44-page grinding mill bulletin 07B6718A is chuck full of valuable tables and grinding mill information. Get it from A-C representative in your area or write Allis-Chalmers, Milwaukee 1, Wis. A-3706

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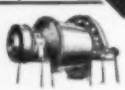
Grinding Mills

Vibrating Screens

Kilns, Coolers, Dryers

Linde JPM-3 May Aid Mesabi Taconite Mining

Large scale mining of Mesabi taconites may have moved nearer to realization with the arrival of the latest model Linde Jet-Piercing machine at Reserve Mining Co.'s Babbitt, Minn. property.

When the machine is placed in operation it is expected to pierce blast holes in the hard taconite beds up to 10 times faster than is possible with existing drilling equipment. The new primary blast hole drilling machine has been designated the JPM-3, and is the successor to the JPM-1, in operation at Erie Mining Co.'s taconite mines at Aurora, Minn.

The size of primary blast holes which can now be pierced has increased from a nominal 6½ in. diameter to 7½ in. diameter and maximum hole depth has increased from 35 ft to 47 ft. Development has progressed to where 7½ in. holes can be pierced with the same speed as 6½ in. holes. Piercing progress is controlled by electronic blowpipe descent controls.

Other features of the JPM-3 include: automatic burner ignition from the operating cab; heated and air conditioned operating cab designed for all-year operation; mechanical improvements for sub-zero operation common to the Mesabi, and redesign of wearing parts for longer service with minimum maintenance. The 40-ton machine is self-propelled. Power, oxygen, and cooling water lines trail from the machine.

Jet piercing is based on combustion products of oxygen and a liquid fuel such as kerosene. The flame, jetting from a burner at speeds of about 6000 ft per sec, disintegrates layers of spallable rock. The burner is cooled by water which is then directed through orifices around the periphery of the burner. The water changes to steam and carries the spallings out of the hole. The equipment used in Jet-Piercing is essentially a tractor-mounted blowpipe containing a combustion chamber and nozzle, which is in effect a miniature rocket motor, from which the supersonic combustion gases emerge to do their work.

New Linde JPM-3 Jet-Piercing machine which will go into operation at Reserve Mining Co.'s taconite mining operation at Babbitt, Minn. The machine may speed up efforts toward large-scale mining of taconite ores on the Mesabi.

A.S.&R. Set To Abandon Bolivian Copper Mine

Blaming serious labor disorders and "poor economic outlook," American Smelting and Refining Co. is closing its Bolivian copper mining subsidiary which operates the Coro Coro mine.

The company said, in a statement released in New York City:

"The principal cause for the suspension of operations is the long history of labor disorders dating back to 1944, culminating in recent weeks in a situation wherein it was necessary for all the managerial and technical staff to be evacuated to La Paz."

In accordance with Bolivian law, which requires ninety days notice of cessation of operations, Cia American Smelting and Refining, S. A., gave notice to the Bolivian Government July 9 it would halt work Oct. 9.

In its statement, the company referred to threatening actions by miners and diminishing ore reserves. American Smelting and Refining has operated the mine since 1934. About 850 men are employed, producing 300 tons of copper concentrates a month.

Bolivian Minister of Mines Juan Lechin accused the company of "bad faith." He charged that the company had "promoted trouble with the workers and forced technicians to abandon the mine, so as to leave the Government facing the workers after resorting to lies against both Government and labor."

Last June, Henry E. Brown, American manager of the Bolivian Tin and Tungsten Corp. mine at Huanuni was severely beaten after a meeting of 2500 tin miners heard that the corporation refused to grant two of their demands.

New general research laboratory of the International Minerals & Chemical Corp., at Skokie, Ill. The laboratory was formally opened recently, and research work is currently being carried on in the building.

Wage Increases Add To Utah Mining Woes

The wage increases and other benefits granted by the Wage Stabilization Board to workers of three Utah underground mining operations have compounded the problems faced by Utah operators, already hit by a decline in lead and zinc prices.

The board announced a general wage increase of 8¢ per hr for employees of United States Smelting Refining and Mining Co., Combined Metals Reduction Co., and New Park Mineral Co. In addition, U. S. Smelting and Refining employees are to get a 3¼¢ hourly increment between job classifications. Increment at New Park and Combined Metals is 2¾¢.

According to operators, the increase will average 21.4¢ per hr at New Park and 16.7¢ per hr at Combined Metals. A ceiling of 18¢ per hr was placed on U. S. Smelting.

Otto Herres, vice-president of Combined Metals pointed out that his company had offered to settle with the union on much the same basis six months ago, when the market price for zinc was 19.50¢ and for lead 19¢. As a result of the WSB action and a price drop, the companies face a 30 to 40 pct cut in net income, he said.

Miles P. Romney, manager of the Utah Mining Association said the decision "sets a pattern in excess of most of the other underground mining operations throughout the country."

Publish Interim Data On Cuyuna Iron District

An interim report, in the form of geologic maps and structure sections, on part of the Cuyuna iron-bearing district in the vicinity of Crosby and Ironton, Minn., can now be inspected, according to Secretary of the Interior Oscar L. Chapman.

The maps and sections are a compilation of geologic data gathered by detailed mapping of the iron mines during the period from July to October 1951. They are being released as an aid to exploration and mining. A map with a scale of 1000 ft to the in. serves as an index map and shows the general geologic pattern of the area. Five other maps, with a scale of 200 ft to the in., show (1) distribution of the several types of rock formations exposed, (2) brief descriptions of these rocks, and (3) many recorded observations concerning their geologic structure.

Three cross sections, at the same scale as the data sheets, show the third dimensional aspect. The materials may be examined at the Geological Survey, Room 2, Crosby Theatre Building, Crosby, Minn.; Room 213, Science Hall, Madison, Wis., and Room 1033, General Services Building, Washington, D. C. Copies are also filed at the office of the Minnesota Geological Survey, Pillsbury Hall, University of Minnesota, Minneapolis, Minn.

Estimate Nigerian Deposit at $14 Per Ton

Geologists estimate that ore from a uranium and columbium deposit recently discovered in Nigeria will contain about $14 worth of the two metals per ton. The field is located about 20 miles from the nearest railroad and is said to cover 200 acres.

If technical problems can be solved, experts feel that production may reach 100 tons of uranium and 2000 tons of columbium per year. It would necessitate handling about 3000 tons of ore per day.

The land is owned by the Nigerian Government but mining rights belong to the British Crown. It is considered likely that British mining firms will be invited to bid for the rights with a share of the profits going to Queen Elizabeth II. The Crown usually turns over such income to the treasury.

Main sources of uranium for Britain now are the Belgian Congo and Canada, both requiring payment in gold. Development of the Nigerian deposits would permit Britain to pay for atomic materials with sterling.

. . . Cores Tell The Story

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with speed and economy is provided by Longyear Contract Drilling Service. Rapid drilling progress is obtained by modern equipment like this new Longyear deep hole drill. Maximum core recovery is assured by skilled Longyear crews experienced in recovering cores from all types of formations.

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The Longyear DH-5 deep hole drilling rig is now available to purchasers who prefer to do their own drilling. Write for New Bulletin.

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MINNEAPOLIS, MINNESOTA, U. S. A.

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GEOLOGICAL INVESTIGATIONS

Du Pont Celebrates 150 Years of Progress

The Du Pont Co., observed its 150th anniversary at the Wilmington, Del., site of the company's first mill, with almost 7000 active and retired employees, and members of the Du Pont family attending.

Representatives from 25 states, coming from as far as the West Coast, saw the dedication of a marker formed by one of the two mill stones ordered from France by the founder of the company, Eleuthere Irenee Du Pont. The stone weighs about seven tons and is mounted on a granite base. It was used to grind, by water power, sulphur, charcoal, and saltpeter for gunpowder, first Du Pont product.

Luther D. Reed, retired recently as director of Du Pont's trade analysis Div., was executive director of the 150th anniversary organization. William A. Hart, Du Pont advertising director, was chairman of the anniversary planning committee. J. W. McCoy, a director and former vice-president of the company, was general coordinator.

One of the features of the Wilmington program was a historic prologue, depicting the founding of the company. Invited guests visited the ground floor of Eleutherian Mills, the house into which E. I. Du Pont and his family moved in 1803, as well as the company's first office building, and the stone house where the founder and his family lived during their first summer in Delaware.

Approximately 6000 of the guests were Wilmington employees with seven or more years of service. In total, representatives came from 71 plants throughout the nation. Du Pont also marked its 150th anniversary celebration with the publication of a book, *Du Pont, the Autobiography of an American Enterprise*. Other Du Pont plants also celebrated the anniversary.

Wabana to Produce 2.8 Million Tons in '52

The Wabana iron ore mine in Newfoundland is expected to produce 2.8 million tons of ore in 1952 from its underwater operations. Mining is carried on under Conception Bay, with four sloping shafts reaching almost three miles out to sea.

The mines, owned by Dominion Steel and Coal Corp., shipped 47 pct more ore in 1951 than in the previous year. The increase was due largely to growth of overseas shipments. Major share of the 696,912 ton increase went to the United Kingdom. Total shipments in 1951 reached 1.54 million tons compared with 1.044 tons in 1950.

Orders totaling 500,000 tons per year for five years have been placed by Germany, with the United Kingdom contracting for 1 million tons per year for a similar period. Dominion Steel and Coals steel mills at Sidney will get 900,000 tons per year. Smaller contracts have also been arranged. Wabana ore is used only on a limited basis in American and Canadian mills because of high phosphorus and silica content.

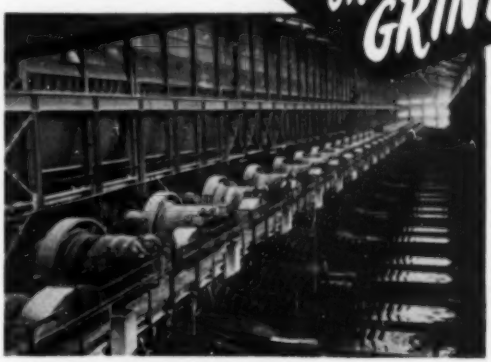
Operations started on Bell Island in 1895, but the shore deposit was soon exhausted, leading to submarine mining. The room and pillar method is currently being used. A conveyor belt system is being installed as part of an expansion program designed to raise production to meet demand by the end of 1952.

Bill Signed Allowing L-208 Damage Claims

The President signed a bill making it possible for gold miners to claim damages suffered because War Production Board order L-208 during World War II forced them to halt operations.

Senate Bill S3195 waives the statute of limitations, and will allow affected operators to go before the U. S. Court of Claims asking restitution for mines damaged by the closure order. Only 17 claims were filed before the U. S. court prior to expiration of the time limit set by the statute of limitations. Some mines suffered permanent damage to physical plant and orebodies.

the "low-down" on GRINDING



At one of this company's properties there are 27—10' x 10' Marcy Grate Discharge Mills, in closed circuit with 54—54" Akins Duplex Classifiers, grinding in excess of 50,000 tons per day.

The acceptance of the Marcy low-pulp-line, rapid-circulation-of-mill-content principle of grinding is proved by the universal use of Marcy Grate Discharge Mills . . . *and the many repeat orders based on output and low-cost-per-ton performance.*

for example:

8-10'x10' MARCYS — 5th repeat order from large Arizona copper producer.

Like many other successful mining companies this large copper producer uses Marcy Mills exclusively. Based upon its years of experience with Marcy Grate Discharge Mills this company has placed 5 repeat orders — now has 69 Marcys giving dependable, low-cost-per-ton performance.

Other MASSCO products: Massco-Fahrenwald Flotation Machines, Genuine Wilfley Tables, Massco-McCarthy Hot Millers, Rock Bit Grinders, Density Controllers, Belt Feeders, Rubber Pinch Valves, Assay and Laboratory Supplies and Equipment, Complete Milling Plants.

The Mine & Smelter Supply Co.

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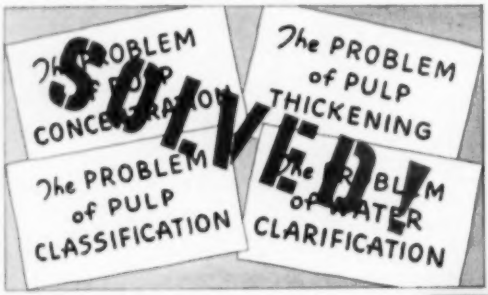


MILLING and ORE DRESSING MEN

Can *Change* WASTE to PROFIT with H+P

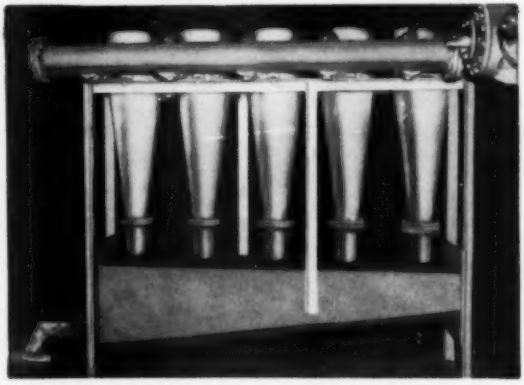
CYCLONE THICKENER EQUIPMENT

Cyclone Thickener equipment is turning waste into profit at a large eastern flotation mill, where agricultural lime is now being recovered efficiently and quickly from zinc and lead flotation tails.

This particular installation consists of eight 14" Cyclones. The Cyclones receive the feed material as a suspension of solids having a specific gravity of 2.50. By rejecting the ultra-fines, which are objectionable, and delivering a concentrated underflow or spigot product, the Thickeners recover approximately 2200 tons of agricultural lime per day. The classification desired and obtained in this operation is 30 microns.

Cyclone Thickeners, which generate forces up to 12,000 times gravity, provide an economical and practical method of controlling solids in Circulating Systems and separating solids from liquids. The Cyclone Thickener's low cost . . . small space requirements . . . minimum upkeep . . . and lack of moving parts makes it the ideal answer to Thickening and Classifying problems.

Heyl & Patterson laboratory and field tests have provided a sound basis for predicting accurately the Cyclone performance on most feeds. For more information send for booklet 5-CT-51 or send us your problem and we will tell you how a Cyclone application can provide the answer.



A typical installation of five 14" Cyclones. Eight of these 14" Cyclones are now being used to recover agricultural lime from zinc and lead flotation tails.

The standard 3" Cyclone Manifold consisting of feed valve, combination feed chamber and overflow chamber, overflow valve, underflow pan and twenty-two Cyclones. The standard 3" Manifold consisting of twenty-two Cyclones has a capacity of 250 G.P.M. and is designed to operate at 40 PSI.

Heyl+Patterson, Inc.

"SINCE 1881"

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HEAVY BULK MATERIALS HANDLING EQUIPMENT

ALL THE WAY FROM DESIGN TO ERECTION

Testing Device Gives Mine Structure Data

A new type of centrifugal testing device may soon provide a method for designing safe, and economical underground mine structures, such as tunnels, rooms, and stopes.

The device was developed at the Eastern Experiment Station of the Bureau of Mines, College Park, Md., as part of the Bureau's program of applying the principles and techniques of physics to mining problems. The principle of operation is that centrifugal forces generated by rapid rotation of a test model produce strains equal to those created in a mine by pressure of surrounding formations.

The device employs resistance strain gages to measure the amount of distortion in the rotating model. The use of the gages make it unnecessary to test a model to the destruction point. It also saves time, money, and labor in preparing and testing models and makes possible application of test results to any underground structure similar to the model, regardless of its dimensions or materials.

Given a ground control problem, technicians can find a solution applicable to a number of mines operating in physically similar surroundings. Information relative to the new device is contained in *Centrifugal Testing Apparatus for Mine Structure Stress Analysis*, obtainable from the Publications Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13.

See Planning Need For Canadian Coal

Long range planning to increase Canada's coal output was suggested by the Dominion coal board in its annual report to the House of Commons.

The board, set up in 1947 to administer coal policy, noted that Canada requires 50 million tons per year, and is now producing only 20 million tons per year. The board said that dependency on outside sources in the past has caused difficulty, and that there is no assurance that this will not occur again in event of an emergency. The board suggested planning for an increase which will bring home production to at least 50 pct of Canadian needs.

Principal Canadian coal deposits are found in Nova Scotia, New Brunswick, Saskatchewan, Alberta, and British Columbia. Known coal reserves are said to be more than abundant. Nearly 90 pct of Canada's bituminous coal is contained in the continuous belt which extends along the continental divide between Alberta and British Columbia.

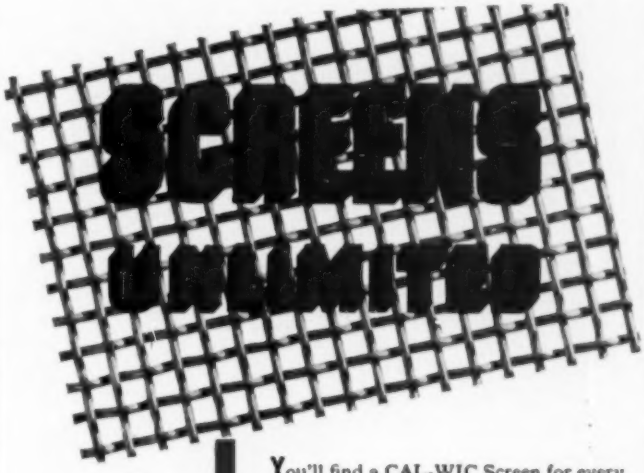
Equipment Shortages Plague Eldorado Mine

Construction of the uranium mine and mill of the Canadian Government's Eldorado Mining and Refining Co., northwestern Saskatchewan, is meeting with difficulties brought about by a shortage of equipment and building lumber.

Equipment shortages were engendered by a four-foot drop in the level of Ace Lake hindering barge transportation. Despite handicaps, the mill and mine is expected to be in operation next year. More than $8 million will be spent during the year on further development.

A third shaft is being sunk in addition to two already completed. A lateral adit in a new find east of present strikes is also being carried out .

Companies now working concessions in the area have until August to stake a certain percentage. After that, it will be thrown open for staking by others. A shaft is being sunk on the Rix-Athabaska Uranium Mines, Ltd., property, and two lateral levels are under development in a shaft of Nesbett-Labine Uranium Mines, Ltd.



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Write for Bulletin No. 507.

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Mining Congress Show To Have 143 Exhibitors

More than 143 exhibitors will present every type of equipment and supply for mineral production and processing at the 1952 Mining Show of the American Mining Congress, scheduled for Denver, Sept. 22 to 25.

Prominently identified with the convention are: Merrill E. Shoup, chairman, Western Div., American Mining Congress; Otto Herres, national program committee chairman; William J. Coulter, general chairman of arrangements; and C. B. Stainback, chairman of the manufacturers Div., American Mining Congress.

Exhibitors scheduled to take part in the show include:

Aero-Coupling Corp., Aero Service Corp., Allen-Sherman-Hoff Pump Co., Allis-Chalmers Mfg. Co. (General Machinery Div.), Allis-Chalmers Co. (Tractor Div.), Alloy Steel & Metals Co., American Air Filter Co., Inc., American Brattice Cloth Corp., American Manganese Steel Div. (American Brake Shoe Co.), American Mine Door Co., American Steel & Wire Div., American Wheelabrator & Equipment Corp., Anaconda Wire & Cable Co., Armco Drainage & Metal Products, Inc., Atlas Powder Co., Barber-Greene Co., Bemis Bro. Bag Co., Bethlehem Steel Co., Bird Machine Co., Bixby-Zimmer Engineering Co., Blackhawk Mfg. Co., Broderick & Bascom Rope Co., Bucyrus-Erie Co., Buda Co., E. D. Bullard Co.

C. S. Card Iron Works Co., Cardox Corp., Caterpillar Tractor Co., Chicago Pneumatic Tool Co., Christensen Diamond Products Co., Cleveland Worm & Gear Co., Colorado Builders Supply Co., Colorado Fuel & Iron Corp., Colorado Iron Works Co., Colorado School of Mines Research Foundation, Inc., Columbia-Geneva Steel Div., Crucible Steel Co. of America, Cummins Engine Co., Inc., Dart Truck Co., Denver Equipment Co., Detroit Diesel Engine Div. (General Motors Corp.), Dings Magnetic Separator Co., E. I. Du Pont de Nemours & Co.

Easton Car & Construction Co., Thomas A. Edison, Inc. (Storage Battery Div.), Eimco Corp., Electric Steel Foundry Co., Electric Storage Battery Co., Engineering and Mining Journal, Euclid Road Machinery Co., Farmers Engineering & Mfg. Co., Farval Corp., Fiske Bros. Refining Co. (Lubriplate Div.), Flexible Steel Lacing Co., Galigher Co., Gardner-Denver Co., Gates Rubber Co., General Electric Co. (Apparatus Sales Div., Construction Materials Div., Lamp Div.), Goodman Mfg. Co., Gould-National Batteries, Inc., Hardinge Co., Inc., Harnischfeger Corp., Herb J. Hawthorne, Inc., Hendrick Mfg. Co., Hercules Motors Corp., Hercules Powder Co., Hewitt-Robins Incorporated, Frank G. Hough Co., Humphreys Investment Co. (Engineering Div.)

Independent Pneumatic Tool Co.,

Ingersoll-Rand Co., International Harvester Co., Jeffrey Mfg. Co., Jones & Laughlin Steel Co., Joy Mfg. Co., Kennametal Inc., Lake Shore Engineering Co., Le Roi Co. (Cleveland Div.), A. Leschen & Sons Rope Co., R. G. LeTourneau, Inc., Link-Belt Co., Link-Belt Speeder Corp., E. J. Longyear Co., Ludlow-Saylor Wire Co., Mancha Storage Battery Locomotive (Div. Goodman Mfg. Co.), Marion Power Shovel Co., Master Builders Co., Mine Safety Appliances Co., Mine & Smelter Supply Co., Mining Congress Journal, Mining Record, Mining World, Morris Machine Works, Morse Bros. Machinery Co., Mosebach Electric & Supply Co., Inc., Murphy Diesel Co.

National Fuse & Powder Co., National Malleable & Steel Castings Co., Nordberg Mfg. Co., Northwest Engineering Co., Ohio Brass Co., Oil Well Supply Div., Olin Industries, Inc., Pennsylvania Crusher Co., Pioneer Engineering Works, Inc., Productive Equipment Corp., Raybestos-Manhattan, Inc. (Manhattan Rubber Div.), Rock Bit Sales & Service Co., John A. Roebling's Sons Co., Santa Fe Tank & Tower Co., Service Supply Co., Sheffield Steel Corp., Simplex Wire & Cable Co., Simplicity Engineering Co.

Socony-Vacuum Oil Co., Inc., Southwestern Engineering Co., Stearns Magnetic, Inc., Stearns-Roger Mfg. Co., Sterling Steel Casting Co., Stoody Co., W. O. & M. W. Talcott, Inc., Texas Company, Thomas Flexible Coupling Co., Timken Roller Bearing Co., Tool Steel Gear & Pinion Co., Traylor Engineering & Mfg. Co., Twin Disc Clutch Co., W. S. Tyler Co., Union Carbide & Carbon Corp., Union Wire Rope Corp., United States Steel Co., United States Steel Export Div.

Universal Dredge Mfg. Co., Vascoloy-Ramet Corp. (Mining Tool Div.), Victaulic Co. of America, Vulcan Iron Works Co., Western Gear Works, Western Machinery Co., Western Rock Bit Mfg. Co., Westinghouse Electric Corp., and White Motor Co. (Sterling Div.)

To Complete White Pine Branch Road by October

The 14-mile branch line under construction by the Duluth, South Shore & Atlantic Railroad Co., from Bergland to White Pine, Mich., is expected to be completed by October, 1952.

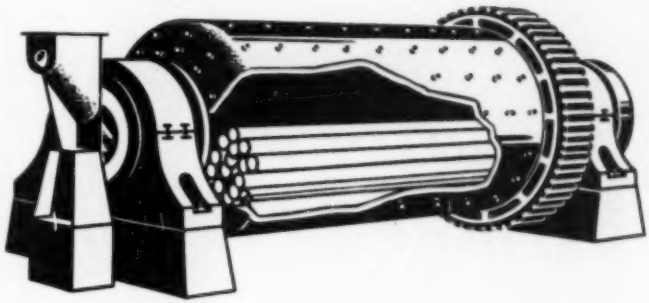
White Pine is the scene of Copper Range Co.'s low-grade copper development. Part of the branch line will run over the old Widmann Lumber Co. logging railroad line. Bergland is on the main line of the South Shore Railroad between St. Ignace and Duluth.

Surveying work is nearly finished and track laying is expected to begin soon. ICC approved construction of the branch line last June.

IS

SIZE REDUCTION

YOUR PROBLEM!



HARDINGE ROD MILLS

Hardinge's recent bulletin on Rod Mills answers the question — "What Happens Inside a Rod Mill?" — and shows how Hardinge Rod Mills solve some of the usual problems.

- Hardinge Rod Mills efficiently prepare products in the 6-mesh to 20-mesh range in open circuit, both wet and dry grinding.
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- Conical heads in Hardinge Rod Mills reduce friction, prevent congestion of charge at the ends, and align the rods.
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Write for Bulletin 25-C-2.

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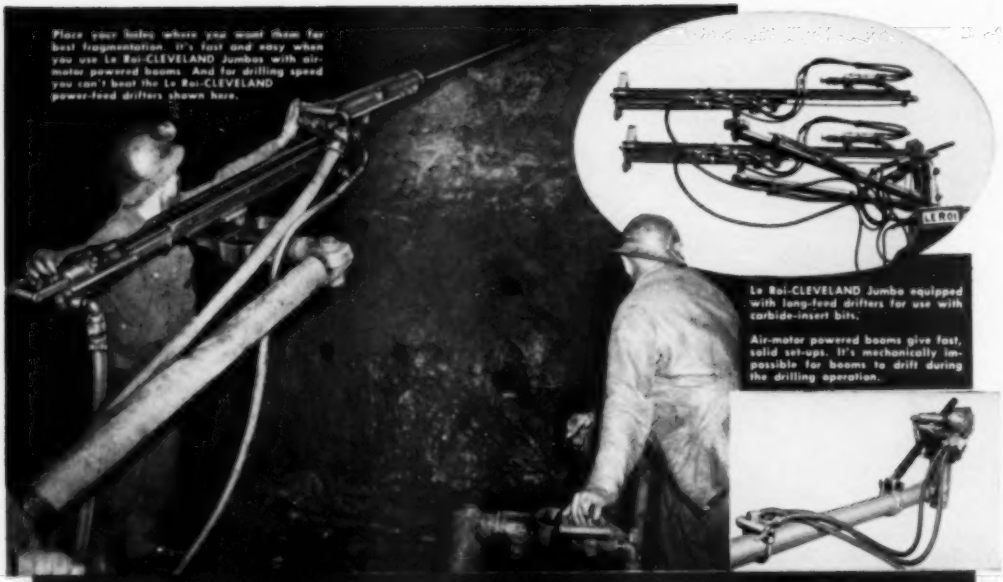
Place your holes where you want them for best fragmentation. It's fast and easy when you use Le Roi-CLEVELAND Jumbos with air-motor powered booms. And for drilling speed you can't beat the Le Roi-CLEVELAND power-feed drifters shown here.
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Let's see what you get when you use Le Roi-CLEVELAND:

★ The most flexible jumbo available. Air-motor powered booms let you space your holes quickly and easily for most efficient fragmentation.

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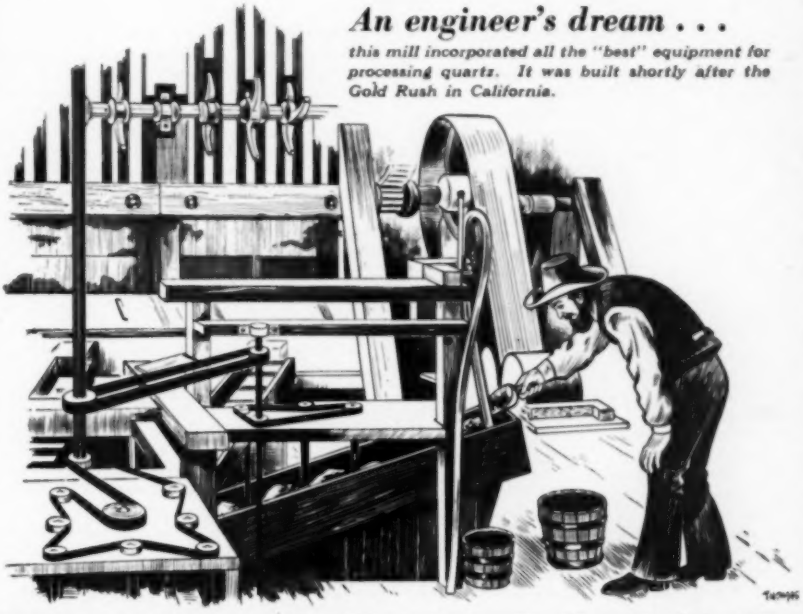
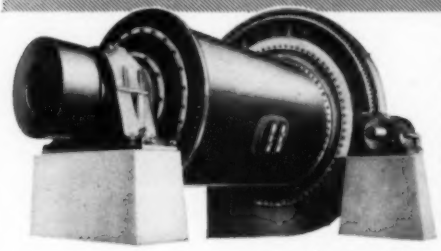
this mill incorporated all the "best" equipment for processing quartz. It was built shortly after the Gold Rush in California.





As great mining developments opened up in our country, the mining industry repeatedly devised more efficient methods to increase production. These improvements in technique came hand-in-hand with the invention of better equipment. For 50 years, Traylor has led in designing advanced crushing machinery to meet the growing demands of the industry. Mining men know that experience is their most dependable guide for matching machines with methods for best results. Traylor has experience . . . half a century of it.

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THE President's Materials Policy Commission dropped a bombshell into the midst of American complacency, and for those who had been hiding behind the myth of inexhaustible natural resources, it came as a shock. But to industrialists, economists, and Government officials who have been observing America's gargantuan appetite for natural resources, it came as no surprise. Sometime during the 1940's the U. S. had outgrown its industrial base. It became what many thought it could never be—a have not nation. Factories consumed more materials than were obtained from mines, forests, farms, and other natural resources.

The Commission took 18 months to complete the report, presented in five volumes and entitled *Resources for Freedom*. William S. Paley, president of the Columbia Broadcasting System, headed the group. One of the basic premises of the report is that by 1975 American industry will be producing twice as much as in 1950. The assumption is based on the fact that U. S. industry has grown at the rate of 3 pct per year since 1900. Americans used more metals and mineral fuels since World War I than the entire world consumed during all of recorded history prior to 1914.

At the predicted rate of expansion the U. S. will need 18 pct more tin, 1800 pct more magnesium, demand for copper, lead, zinc, and iron will rise about 40 to 50 pct, bauxite 400 pct, and fluorspar 300 pct. While doubled consumption and production will not double the need for raw materials, it will demand an overall increase of more than 50 pct. A 90 pct increase in minerals demand is expected. The Commission predicted a re-emergence of demand for coal, with a 60 pct increase anticipated by 1975 as supplies of petroleum and natural gas diminish and become more costly.

The vital factor involved is not depletion of raw materials, but the zooming cost in producing them. To scratch every last bit from the land would mean an ever increasing total of necessary man hours. The report points out that in no important material does the U. S. face an absolute famine. But getting what is needed will force a shift from time spent producing the things people want, to a state of intensified working of native resources.

This is one of the three expedients offered by the Commission. Another choice would be switch to use of materials in more abundant supply rather than continuing to exhaust those in short supply. Technology offers aid in both instances. Deeper mining is recommended by the Commission. Metallurgists have developed substitute materials. The Commission urges increasingly militant research of all kinds. There is a third choice. And it brings up one of the oldest battles on the American political scene. The U. S. would have to overhaul, modify, and in many cases discard sections of its import tariff structure.

The U. S. has a protective tariff on many raw and semiprocessed minerals. In most cases the domestic buyer finds that in the final analysis he pays the tax on the material via increased buying costs. Among the minerals taxed are mercury, fluorspar, and manganese. Americans must face the fact that supply of these, and many other vital materials will depend more and more upon imports. In a sense, the U. S. will do much of its mining at seaports. Action on this front is inhibited by a holdover from the Depression, the Buy American acts. Thus, the U. S. quickens the pace of domestic resource depletion, while hardly touching undeveloped foreign sources. Fundamental in the Commission's recommendations is the repeal of those acts.

The Commission summed up its position by saying, "there is no such thing as a purely domestic policy toward materials that all the world must have. Whether we discuss minerals, energy resources, timber, land or water we face only world policies which have domestic aspects."

The Commission also anticipated the effects of a war within the next 25 years. War would alter the supply and demand picture quickly and drastically. But even if peace were guaranteed until 1975, raising of Europe's standard of living to that of the U. S. would increase the demand for materials.

The Commission stated that American private enterprise must carry the major burden of developing resources in foreign countries, but it also recognized that certain dangers to investment exist. Since World War II American investment in foreign mineral development has averaged $50 million a year, and has been steadily increasing since 1948.

The Commission was strong in its denial of alarmist intentions in citing the steady depletion of natural resources. Its attitude was one of "serious concern," but it reported that with a proper combination of initiative, prudence and cooperation abroad, the problem could be solved.

The Paley report stirred up a great deal of comment, controversy, and condemnation—but little or no action. Congress was much too busy closing up shop for vacation and a little fence repairing to read the report. One business newspaper was unequivocal in its denunciation of the report, saying of the Government that ... "if it will get its fat, stupid self out of trying to govern economic matters, the people, left to themselves, will find ways to accommodate themselves to changes just as they always have ... "

The importance of the Paley report will be adjudged in the next 25 years. Its outstanding contribution seems to be its reference to the tasks and opportunities before technologists and scientists.

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DEEP in the Pennsylvania Dutch country, around Lebanon County, an era in American Mining history is coming to a close. The great iron ore deposits, which have yielded more than 60 million tons from open pit operations, are almost exhausted. More expensive underground mining will be needed in the region where Peter Grubb made a treaty with the Indians in 1735 "to use the red dirt as long as grass grows and water flows."

Thousands of tourists come to Cornwall each year to see the pit and the Cornwall charcoal iron furnace, which celebrated its 210th anniversary this year. The furnace is in such a fine state of preservation that it could be placed back in operation within

a week—if workers who could run it could be found. The furnace went into operation in 1742 and made its final blast in 1883. It might be termed the first arsenal of democracy. Forty-two cannon were cast and shipped to Philadelphia during the Revolution. On the shop bulletin board an announcement is still readable:

"Gen. George Washington and General Lafayette will be here on Monday to see the casting of the (day's) first cannon."

The operation of the furnace was simple. Buildings are on a steep hillside, with runways entering at several levels of the plant. The weighing and charging room is at the top level. Twenty loading carts and old scales are still preserved in the room. The charge was made up of ninety lb of limestone, 500 lb of iron ore, and 800 lb of charcoal. About 35 charges a day went through the top of the furnace.

Peter Grubb's cold blast furnace is the oldest in the United States, and in operation for 141 years, but its record is surpassed by the 700-ft deep open pit mine on State Route 322. The mine has been worked for more than two centuries.

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FRENCH steel makers are ready, to support the Schuman plan. Pierre Ricard, vice-president of the French Steel Chamber syndicate, announced the industry's readiness to cooperate with the plan, which is aimed toward giving Europe an integrated steel industry. Steel men appear to have decided in favor of the plan because of its promise to unify the continent.

Behind approval is the emphasis placed by French steel plant operators on continuation of the Franco-Saar economic union. The French have an abiding fear of German steel production potential. France is currently producing at an annual rate of 11 million tons, while Western Germany is producing 15.5 million tons of steel. The Saar output is placed at 3 million tons.

French industrialists feel that as long as the marriage of French and Saar steel production continues, France can compete reasonably well with Germany. If Saar production should suddenly become part of the Western Germany total, it could result in an unequal competitive situation, giving Germany a production level of 18.5 million tons of steel annually, or 60 pct more than France.

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IT is estimated that about 50 million lb of molybdenum, which would have been otherwise lost will go into the Government stockpile as the result of a contract between Defense Materials Procurement Administration and Climax Molybdenum Co. Jess Larson, administrator of the DMPA, said that Climax agreed to spend up to $9.5 million for additional facilities to produce 17 million tons of low-grade ore from its Lake County, Colo., properties. The Government, in turn, will purchase the concentrates if they meet stockpile specifications.

The cost of processing and mining the ore, situated in Climax's mountain properties, is so high the company probably would have abandoned them without Government assistance. Operation would have continued on another level of the orebody. The initial output will be purchased at $1.24 per lb of contained molybdenum. Larson said he expected the price to decline to between $1 and $1.07 once the operation is in full swing. The present market price is $1 per lb of metal contained in concentrates. The U. S. produces more than nine-tenths of the free world's supply of the metal.

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TRENDS last month said, "(Bolivia) served notice that it intends to be pretty tough to deal with in the future . . . The order seems to be a prelude to the nationalization of the mines . . . The Bolivian Government can expect only that it will drive away foreign investors." These lines referred to the Bolivian Government monopoly on export and sales of minerals. American Smelting and Refining Co. recently announced cessation of its copper mining operation in Bolivia, declaring the mine uneconomic and the personal safety of employees at a low state. For a complete story see page 749.

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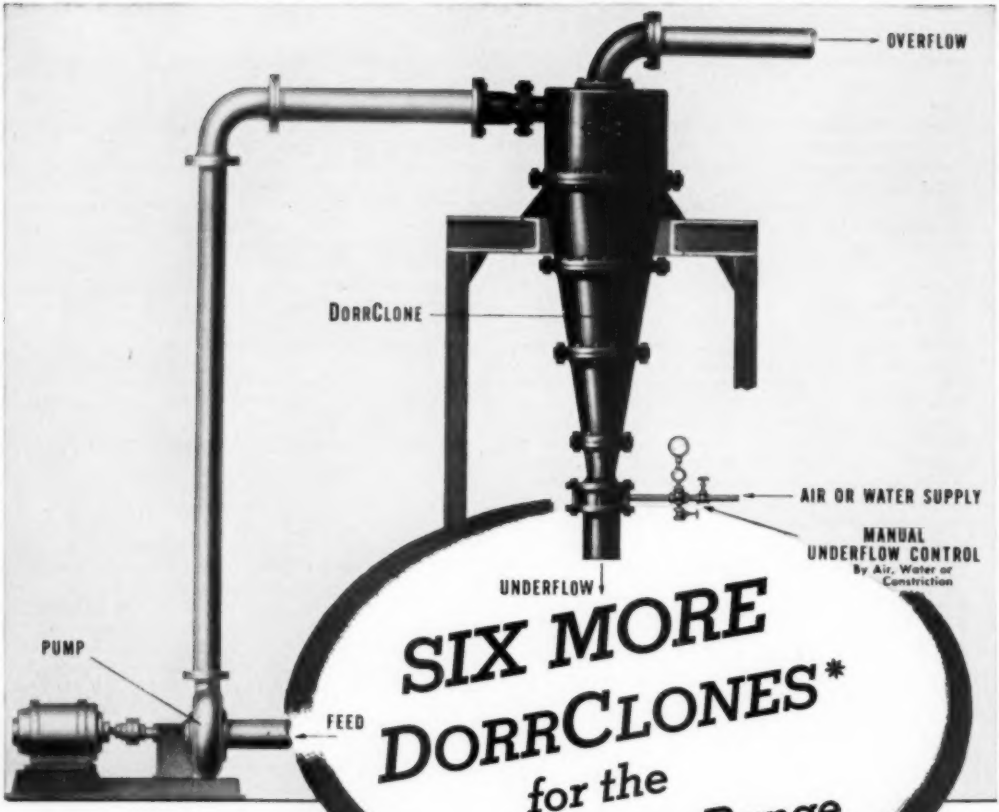
ONCE, not too long ago, a fellow named Karl Marx wrote a rather interesting book called *Das Kapital*, containing some highly pertinent criticisms of capitalism. Today, many of the faults he pointed out have been corrected. That is, they have been rectified in countries other than the ones carrying on "the great experiment."

Official Soviet data, published in the Yugoslav Review, May, 1952, in 1950 says that the average worker's salary came to 500 rubles a month, or about $125.00. Lowest paid workers in the machine industry received about $33.23 and in mining about $62.50 a month. However, men in managerial positions, directors of enterprises, receive a basic salary of 2,500 rubles or $625.00 a month. Special bonuses boost salaries tremendously, according to the official data. Bonuses make up as much as 51.4 pct of salary funds in metallurgy, 45 pct in light industry, and 42 pct in the chemical industry. Directors of enterprises receive automatic bonuses equal to their monthly salary for each fulfillment of the monthly plan, raising their incomes to $1,250.00 a month.

Mining and metallurgy directors receive a 25 pct rise in salary for each 1 pct reduction in production costs. If the annual plan is fulfilled, leading bureaucrats are rewarded an amount equal to their three-months salary. Salaries paid to the top production bureaucrats are 16 times higher than workers salaries and 55 times higher than the minimum salary paid to machine industry workers. But then, the worker always has the chance to become a hero, Russian style, by producing the equivalent output of three workers.



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RESULT — *Extensive test work on a 24" dia. DorrClone resulting in an order for six additional 24" units.*

At Cleveland Cliffs Iron Company's Canisteo Washer, a 24" dia. DorrClone was installed on a test basis to determine the desirability of desliming their classifier overflow prior to conventional fine ore treatment. Standard hydroseparation was impossible without considerable dilution as these overflows contained a high percentage of solids.

The DorrClone was required to make a satisfactory size separation on feeds varying widely in both percent solids and structure. During the tests, solids varied from 17-35% and +200 mesh in feed varied from 25-35%. The Beneficiation Engineer at Canisteo reported that "after initial adjustments, these variations seemed to have little effect on the operation . . . the DorrClone operated very satisfactorily."

If you have a desliming problem, there's a good chance that the DorrClone, with its high capacity-for-size and ability to handle flocculant or heavy pulps, will be the solution. For further information write for bulletin No. 2500. The Dorr Company, Stamford, Conn.

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MINING
ENGINEERING

EDITORIAL

EDUCATION — THEORY OR PRACTICE

EDUCATION is a business; and, if the consumer is satisfied with the product, no one has any grounds for complaint. "Pretty well satisfied" about sums up the attitude of the mining industry toward the young graduates presently entering the field. Yet, with amazing regularity the controversy over the five-year curriculum recurs in educational circles. The educational mills grind out their products, some higher grade than others, depending on individual proclivity. The cycle continues *almost* without interruption.

Arthur Taggart, however, takes his bowie knife to some of the sturdiest limbs of the tree of knowledge in his article on engineering education on page 770 of this issue. As all who know him might suspect, the pruning is not restrained. With one swing of the knife, such practically-labeled courses as Mine Design are stricken from the tree and transplanted to the field of Graduate Education. Emphasis on the basic sciences and the study of man through courses in history, economics, and literature are recommended to constitute an undergraduate curriculum. Such courses show the least depreciation and therefore give the student the most for his money. Partial justification for this dramatic departure from tradition is explained by the increasing number of companies giving training courses. Why make the student pay for what he can get paid for learning after graduation, the author argues.

Other leading educators espouse this doctrine. Dean S. C. Hollister of Cornell, for the Committee on Adequacy and Standards of Engineering Education, recommended to ECPD in 1951 that emphasis be placed on the basic sciences. "Sifting back through the curriculum, it seems clear that instruction in the basic sciences, if taught in a manner such that knowledge of them makes available working tools, contributes the most sustaining part of the curriculum", reported the committee. Note that he would utilize practical problems from the fields of engineering in teaching the sciences.

In our opinion the important thing to learn in college is how to think—*the engineering approach*. Recitation on traditional solutions of classic problems sharpens the memory, not the ingenuity of the student.

The engineering schools of the nation recognize the advantage of great emphasis on fundamentals, and the inclusion of cultural courses in the curriculum. However, industry presently requires graduates to have a substantial knowledge of the tools of the trade upon graduation. This means that the colleges are forced to pare to the bone to encompass the required studies in the time allotted. In addition, there is the limitation of student money. College educators also claim that entering freshmen are often improperly prepared in such subjects as writing and mathematics. These considerations make it difficult for the critic of the engineering graduate to make any headway with the educators.

Actually with the mounting problems imposed by lower grade and more complex ores, a new breed of engineers is needed. The impetus for this new product must come from industry. If there was a concerted effort from industry for an improved type of engineer, the colleges would modify their aims to meet the demand for the kind of individual desired.

Mine Reports

by Samuel H. Dolbear

THE purpose of a technical report is to record facts, usually collected by investigation, and to interpret these facts in understandable language. The audience may range from a small shareholder without technical knowledge, to a highly trained engineer or geologist. If the client is a mining company with technically trained executives, the report writer's problem is relatively simple. The writer will then be appraised not only for his conclusions, but for clarity of language and organization of the report. If the writing is bad, the construction careless, and there is a failure to clearly convey to the reader the facts and the author's conclusions, the report is a failure and the writer may have damaged his professional character.

Spoken words die quickly, written words may constitute a permanent record and if they are badly composed they may rise up to damn the author. "A good measure of an author's understanding of his subject is his ability to express it clearly in plain words."

Good English

Teachers in the fields of mineral technology have frequently complained that even in post-graduate groups there is an appalling indifference to their appeals for good English. Some have even noted a student's belief that the use of refined English is effeminate. If those with such immature beliefs could measure the pay-check damage arising from the use of "sloppy" language, they would realize that precision and refinement in English may be quite as important as technical accuracy.

When the reader audience is without technical knowledge simplicity in treatment becomes especially important. If one is engaged in consulting work, in government service, or in any field where reports have public distribution, the language employed should be technically adequate but simple enough to be understood by non-technical readers. For example, one may use the term "visual" in place of "megascopic." Technical language can be so obscure that it cannot be understood even by highly-trained students. In the March-April (Vol. 47—No. 2) issue of *Economic Geology*, Nicholas Vanserg ridicules these extremes and quotes various paragraphs from published material, such for example: "However, lattice orientation unaccompanied by cognate dimensional orientation can never be attributable to growth from an isotropic blastetrix." "The temperature declines because of cessation of the exothermic chemical and mechanical equilibriopetal processes."

These he calls "good geologese" and they are calculated not only to baffle the reader but to impress upon him the erudite character of the author.

Revision

In some cases, difficulty arises from the fact that the writer is too close to the subject and unconsciously assumes that his reader is equally familiar with the background of the report. It is difficult for the writer to regard his work objectively and to determine to what extent it is likely to be understood. Every important manuscript will gain in clarity if the author will have it reviewed by an informed reader. But the writer must not be oversensitive to criticism and should not treat his composition as perfect and beyond the possibility of improvement.

MR. DOLBEAR is a consulting engineer in New York City.

The first draft of a report always requires revision, regardless of the care used or the ability of the writer. Three or four revisions are not uncommon. The first draft usually requires expansion in places, the deletion of non-essential material, and language changes to promote clarity of expression. This should be done by the author after a lapse of time, even if only overnight, in which his mind has been occupied on some other subject. Possible improvements are always more visible. The manuscript should be passed on to another reader for further suggestions.

Organization of Material

The engineer should study available reports and library references before going into the field. If the previous reports have been responsibly done and can be accepted as correct, then much field time can be saved. It is, of course, customary to make some on-the-ground checks to confirm earlier reports, particularly those relating to ore reserve which may have undergone changes.

Report writing requires time and expense, but nevertheless, the basic reasons for conclusions should be presented even in the case of a worthless property, for it may prevent a duplication of the work. If the mine examined is obviously of no further interest, no useful purpose can be served by preparing a report in detail. In one case an engineer travelled all the way to South America only to find that the mine had been grossly misrepresented and was valueless. His cabled report "Nonsense" is a case of oversimplification, but it served his company's purpose.

The first step in report organization should be the selection of subjects. This should be done at the mine, and the data collected for each subject should be reviewed in considerable detail on the ground. Otherwise one may find that he has failed to collect some essential details not readily obtained after he has returned to headquarters.

If the property to be described is undeveloped, then many of the subject titles are automatically eliminated. Usually no useful purpose is served by an attempt to calculate the cost of production under such circumstances, although the cost of exploration

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The key to a good report is organization. The raw materials of the report must be given form so that they present a coherent picture to the reader. Mr. Dolbear suggests one approach to organization, presented here in outline.

and development and an estimate of capital required should be included if further work is recommended in the report.

In these days of uncertainty, the report may require discussion of the attitude of governments toward private enterprise, nationalization, overtaxation and restrictions imposed on currency, all of which provide elements of risk that may reduce or destroy the value of enterprises.

Oftentimes the larger mining concerns interpret these economic factors at a higher level, and depend on the engineer for only the basic factors of reserves, operating conditions, direct costs, and related data.

Decision as to subjects for inclusion in the report is a matter of fine judgment on the part of the field engineer or geologist. If the report has an economic objective, then one should avoid the inclusion of any extended discussion of purely scientific matters, often a temptation to the geologist. The object of mining is to produce minerals at a profit, and unless the subject matter is related to that objective, then it can usually be omitted.

In many cases subject headings need to be found to cover unusual features or those characteristics of the mine or area. The study of industrial minerals often involves economic and technical problems not present in metal mines. Market prices are frequently difficult to determine, being the result of negotiation between buyer and producer. Many published quotations are approximations and should not be used

for economic estimates without investigation. Color and texture may influence the price. Factors such as these require additional subject titles to be determined before going into the field.

Illustrations

Plans should be made in advance for the preparation of maps, photographs or other illustrations, since these take time to produce, and should be mentioned in the text.

The use of statistical tables requires careful consideration. Many engineers have a tendency to employ statistics without adequate discussion of their significance. Even though the figures may appear to the author to provide obvious conclusions, the reader should not be left to struggle with the interpretation of tables.

Often, comment may be limited to some simple statement such as: "Reference to Table I, page 42, shows that production was at a fairly uniform rate until 1945 when output fell off sharply. This is attributed to a drop in price."

It is important to present subject matter so as to permit uninterrupted sequence of thought for the reader. This is not possible if one must stop to analyze statistics before proceeding with the text. Usually such interruptions make it necessary to reread paragraphs to restore the chain of thought.

Graphs are useful as a supplement or substitute for statistical tables. A few photographs may show terrain, ore exposures, or physical improvements.

Avoid such needless timewasters as—"as stated below" for the reader must either ignore them or he must take time to find the references. And too often the writer's intentions are good when he writes "as stated below," only to omit the later reference through oversight.

Actual Writing

One has the choice of tools for expression—pencil, typewriter or dictation. A pencil is to be preferred even if it is somewhat more laborious. The pencil has the advantage of mobility in correction as one proceeds. Dictation is the least mobile, and there is inevitably the inclusion of errors both by the dictator and the stenographer, with a further hazard due to the use of technical terms.

Much has been published on the organization and writing of technical reports. Most of these publications are concerned with subjects other than the mineral industries and are of little value to mining engineers and geologists.

The author believes the most useful publication directly related to the preparation of mineral reports is *"Suggestions to Authors of Papers Submitted for Publication by the United States Geological Survey"* by Bernard H. Lane, Fourth Edition, 1935. (U.S. Government Superintendent of Documents.) While directed primarily to geological papers, it is useful also to authors of mine reports, for whom, unfortunately, no equivalent publication is available.

Report "Do Nots"

The following suggestions are based on the reading and writing of a large number of reports and should be used where possible.

1—Positive rather than negative statements should be used.

The vein is not as wide on the tenth level.

The vein is narrower on the tenth level.

2—Do not assume responsibility for hearsay evidence even if it appears to be authentic. Instead, either quote the source of the information or state that it "is reported to be," "is said to have produced."

3—Avoid repetition of words. This is difficult in cases where there is a scarcity of synonyms, as for example mine, ore, geology, etc. In addition, there is the tendency to repeat such words as occasional, nevertheless, obvious, and other words characteristically present in the author's vocabulary.

4—Avoid the vernacular, slang and localisms. Such words and expressions have no place in a technical report.

5—Value, weights and measures may be given in terms common to the country in which the mine is situated or those customarily used by the client, or both. In many places, costs include payments to labor in cash, goods and services; and these need reduction to a common cost denominator. It is important to state if weights used are metric, long or short tons.

6—Spelling should conform when possible to the usage of the client. British clients, as a matter of courtesy, are entitled to see labour, cheque, etc., in their reports.

7—Personal pronouns are to be avoided in reports. This helps to maintain an objective viewpoint for both reader and author.

8—If the report is to serve non-technical readers, some explanation of technical descriptions should be provided insofar as it can be done briefly. Thus the significance of the presence of primary or secondary ore should be made clear. If technical terms such as hypogene, supergene, mesothermal, hydrothermal, and ultrabasic are used, a brief explanation should be provided.

The report should, under ordinary circumstances, go into a detailed discussion of ore genesis only to the extent that it is related to economic problems.

9—Confine figures to reasonable limits. Gold in ounces should not be shown for more than two points to the right of the decimal since sampling is outside of that degree of accuracy. And it is a waste of time to produce intricate or extended calculations that have little influence on ultimate value.

10—Avoid inexact terms. Large, small, deep, shallow, rich, lean, long, short, or other adjectives such as these, mean little unless the writer provides a yardstick for the reader. And no mine is to be described as a good mine (or a bad one), although it may be described as profitable or valueless, as may be the case. If its performance or outlook for profit is favorable, provide the facts, including the profit per ton, the investment required, and the annual expected dividend and the life of the operation.

11—Although not a common fault, occasionally reports "wax poetic" in describing topography, climate, picturesque people and areas. It is better to leave this to novelists and authors of travel stories.

12—A table of contents is usually sufficient in short reports. In a long report treating many subjects, there should be an alphabetic index with adequate cross-references. This is preferably placed at the beginning of the report.

13—Where references have been made, a bibliography at the end of the report is useful. Unless the title of the reference is sufficiently informative, a brief summary may be included.

Other suggestions of this character may be found in "Suggestions to Authors" and in *"A Guide to Technical Writing"* by T. A. Rickard (1908).

Spirals Recover Heavy Mineral By-Product — Kings Mountain, N. C.

by W. R. Hudspeth

AS an outgrowth of its spodumene recovery operation at Kings Mountain, N. C., Foote Mineral Co. has been recovering a heavy mineral by-product. Foote leased this idle plant in 1951, reactivated it, using a new spodumene recovery process, and purchased plant and properties in October 1951.

While the operation at Kings Mountain is primarily concerned with the production of spodumene concentrate, pilot plant work determined that the pegmatites also contained heavy minerals including cassiterite. Plans were made to recover the heavy minerals as a by-product and the flowsheet incorporated these facilities when the mill was modified for the new spodumene recovery process.

The orebodies consist of spodumene, feldspar, quartz and mica. Apatite, tourmaline, and beryl are present in small quantities. The wall rock is predominantly hornblende shist. The heavy minerals, including cassiterite, columbite, pyrrhotite, monazite, pyrite, and rutile represent about 0.2 pct of the ore. The fine-grained heavy minerals are disseminated throughout the dikes, apparently unassociated with the spodumene.

The pegmatites are quarried and secondary breakage is by mud-capping and block-holing. Power shovels load into trucks transporting the ore to a coarse ore bin. A Telesmith 10x36-in. apron feeder delivers the ore to an 18x36 in. Traylor Jaw crusher adjusted to discharge −3 in. product to a primary conveyor. The conveyor delivers to a 4x5-ft Tyrock single deck vibrating screen using ¾ in. cloth. The screen undersize is elevated to the crushed ore bin. Screen oversize goes to an Allis-Chalmers Hydrocone Crusher fitted with 4 in. concave and set to deliver approximately 66 pct minus ¾ in. The crusher discharge returns to the primary conveyor. The crushing and screening installation has a capacity of about 60 tons per hour.

Spirals

The crushed ore is delivered at a rate of 350 tons per day to two 6x8-ft Hardinge Pebble Mills, equipped with 20 mesh Ton-Cap trommel screens. The screen oversize is pumped to a 12-in. hydroclone for primary desliming. The hydroclone underflow is diluted to 45 pct solids and distributed to the spirals. There is no heavy mineral loss in the hydroclone overflow.

The spirals bank consists of eight 5-turn Model 24-A Humphreys Spirals. The top port and the last four ports of each spiral are blanked, the remaining nine port splitters are adjusted to remove about 5 pct feed weight. The heavy mineral rougher concentrates are upgraded on a Deister Overstrom table. The spiral concentrates contain approximately 4 pct heavy mineral, and the spiral reject, which goes to another section of the plant for spodumene recovery, contains about 0.03 pct heavy mineral.

There is an interesting feature in the spirals installation. An adjustable splitter mounted on the discharge boxes splits out a mica fines product containing very little heavy mineral. The mica product is cleaned by spiralling and screening. Thus the spirals recover two products; mica, and a heavy mineral rougher concentrate.

Table Treatment

The rougher spiral concentrate goes to a Deister Plato table, modified to receive a Deister-Overstrom No. 6 rubber cover with sand riffles. The table is operated with a 5/8 in. stroke, 270 strokes per minute, and a slope of ½ in. per ft from feed to tailings side. There is no slope adjustment from motion to concentrate end.

Wash water consumption is relatively high, since the large spodumene grains tend to report with the fine heavy minerals. A middling band about 4 in. wide is maintained in order to produce clean concentrate. The middling, representing about 10 pct of table feed, is recirculated by air-lift. A band of concentrate grade coarse spodumene occurs just below the middling. This is removed and delivered to concentrate storage. The table tailing, containing approximately 0.7 pct heavy minerals, is returned to the spodumene feed preparation circuit.

The heavy mineral table concentrates are approximately 45 pct cassiterite, 33 pct columbite, 14 pct pyrrhotite and 8 pct monazite, together with some rutile, pyrite, and copper from blasting wire. Concentrate is collected at 24 hour intervals and dried. If the concentrate remains in wet storage appreciably longer surface oxidation takes place which seriously interferes with the subsequent magnetic separation process. About 150 lb of heavy mineral concentrate is produced per 24 hours and shipped to the company's plant at Exton, Pa. for final separation into tin and columbium concentrates.

MR. HUDSPETH is Mill Metallurgist for Foote Mineral Co., Kings Mountain, N. C.

Maintenance and Training Pay Safety Dividends For Benson Mines

by W. R. Webb and M. O. Peterson

WHEN men drive haulage equipment ranging up to 22 tons in an open pit operation, they must live with the realization that their safety is dependent upon the machines they drive and how well they operate them. The hazards inherent in their jobs must be recognized, met, and defeated. It comprises a never ending struggle toward perfection—an almost unobtainable goal. The Jones & Laughlin Benson Mines, at Adirondack State Park in New York, created a safety program which resulted in only one three-day lost time accident from April 1948 to April 1952.

At the very start of the program, management of the open-pit operation recognized the hazards existing at Benson. The program was designed to meet each danger. With a knowledge of the problem faced, the process of minimizing each facet was planned along lines of maintenance of equipment and training of personnel. Its success is evident. In the ever-present struggle, care and maintenance of machines and application of experience to new equipment design are mainstays.

Truck Haulage

Benson produced 2.9 million tons of crude iron ore and 1.6 million tons of waste in 1951. To do the job, truck mileage reached 500,000 miles. The tremendous mileage emphasized to safety planners, the fact that the more work done, the greater the possibility of risk in haulage operations.

Instrumenting the aim of the safest equipment possible is a methodical servicing program. Like other segments of the drive, the servicing program is based on *greater production* with *fewer accidents*. Every truck is serviced at least once per eight-hr shift. Examination includes inspecting and tightening wheel studs, checking tires, steering apparatus, lights, brakes, wipers, heaters, fire extinguishers, and refueling. A running history of the equipment's operating life is kept in the form of service and maintenance records.

MR. WEBB and MR. PETERSON are General Superintendent and Personnel Director, respectively, Jones & Laughlin Steel Corp., New York Ore Division, Star Lake, N. Y.

Machine operators are constantly on the alert for malfunctioning of units. At the first sign of trouble the truck is returned to the garage for exchange. No truck functioning incorrectly is kept on the line, regardless of its shift check schedule. The program resulted in a reduction of the number of costly overhauls and cut down the number of haulage accidents.

Miscellaneous Mobile Equipment

Auxiliary units, operating within the pit, have presented definite safety problems. The highest accident rate in the pit occurred on trucks carrying water and bits to the churn mills. The weight and awkwardness of bits and drill stems, combined with remote delivery points were direct causes of numerous accidents. Here, the problem has been one of equipment handling, rather than haulage.

All air compressors for secondary drilling are truck mounted, facilitating mobility. In addition to making it easier to move the equipment, truck mounting has eliminated many of the hazards connected with relocating machinery. By making air compressors independent of other units, drilling operations have been speeded up considerably.

Unseen rocks in the path of moving vehicles are a constant source of tire damage. At Benson the problem has been met by supplying each loading crew with a bulldozer for cleanup operations. The pitman directs the dozer operation, and when truck drivers back into loading areas, he serves as an extra set of eyes.

Modern Truck Garage Provides Drive-Through Service

Simplicity is the essence of any preventative maintenance program. At Benson, a modern garage, with a drive-through service bay simplifies servicing. Shift inspection of the 22-ton haulage units is accomplished with minimum delay and maximum thoroughness.

Major repair work and periodic overhauls are done in the repair section of the truck garage. Crane facilities for handling heavy assemblies ease the job and add to the safety factor. Other mobile machinery,

including tractors, graders, air compressors, and miscellaneous service trucks used in the plant are serviced in the same bay.

Safety is the primary consideration in the truck garage. Tire inflating stalls designed specifically for the Benson garage by employees, dollies for handling awkward assemblies, movable work platforms, and service pits help to reduce the risks inherent in heavy equipment maintenance. The special tools found in the garage are primarily safety devices. They function as labor saving devices secondarily.

Road Building Is Important Feature

Construction and maintenance of good roads is undeniably one of the most important contributors to the reduction of haulage risks. It has been found at Benson that run-of-mine rock for a base and crushed waste rock for surfacing make roads which efficiently handle heavy haulage units. Approximately 75,000 tons of crushed stone is used annually for surfacing. Crushed ore is used for roadway surfacing in the pits.

Trucks haul over Benson open pit roads 24 hr a day the year round. Thus, road construction must take into account the requirements of night and winter driving. Road patrols remove rock falling from haulage units in transit. Close side clearances are avoided to permit snow removal. Road graders are in constant use to keep the roads smooth and to remove winter snow. Snowplows are available when snow goes over grader depth. Rubber-tired bulldozers take care of mining and parking area snow. Winter traction problems have been eliminated to an extent with the use of calcium chloride, with or without sand.

Use of Scotch light signs and markers have proved of great assistance to drivers when snow and fog limit visibility.

Iron clad rules-of-the-road speed up haulage without creating safety hazards. Haulage units have the right-of-way over all other traffic, except blasting crew trucks. Regular highway traffic devices, such as stop signs, control vehicle movement.

The sum of experience at Benson is that successful operation of mobile equipment is dependent upon type of roads, traffic control, markings, and regulation enforcement, whether on a highway or open-pit haulage route.

Throughout Jones & Laughlin, the safety program rests on bringing its importance home to the employee—he must be made safety minded. A series of meetings, training programs, and demonstrations are integrated into the employee's working schedule.

Employee Training

When Jones & Laughlin reopened Benson Mines in 1944, the company faced a decided shortage of skilled labor, extending to men capable of handling heavy trucks. Benson is located in a remote area of New York State's Adirondack Park, where the type of skill required was unavailable. To overcome the difficulty, an instruction program was established to train driver applicants. Experienced drivers were assigned to new employees so that the truck crew could be built rapidly and mishaps because of untrained drivers kept down.

The development of a stabilized crew has permitted bringing drivers through a gradual stage of development. Their training starts with service and stripping trucks and eventually they progress to larger units. The need for formal instruction has been decreased but not eliminated.

Although the training program proved costly and time consuming, the resulting crew has been sufficient compensation.

Mining Magnetite and Martite

Mining operations include stripping of earth and barren rock, primary drilling and blasting of ore, and some secondary drilling and blasting for loading. Five-cu yd electric shovels load ore into 22-ton Euclid trucks.

Ore beneficiation involves four stages: Crushing; grinding to bring the ore to concentrate size; magnetic separation to concentrate the magnetite ores, and sintering to agglomerate the relatively fine particles.

Plant facilities were expanded in January 1952 to beneficiate the non-magnetite martite ores encountered in the orebody. An elaborate Humphreys Spiral plant was installed to concentrate the martite ores. The final product of the new plant is sintered in the same manner as the magnetite concentrates.

Currently, 650 men are employed in the mine and beneficiation plant. When the present expansion program is completed, a crew of 700 is expected to be employed.

Twenty-two ton Euclid truck, being loaded at one of the Benson pit faces, must be thoroughly maintained and carefully driven if safety program is to pay dividends. In 1951 trucks like this travelled 5¼ million under load ton-miles.

Education For Engineering

- Should be devoted 50% to basic sciences
- 50% to study of Man through literature, history, biology, economics
- Relegate specifics to graduate work

by Arthur F. Taggart

ENGINEERING education today is like a crazy quilt of somber wools and gaudy shoddy, chain-stitched on an academic assembly line, and sold at ever mounting prices to inexperienced youths for lifetime use. Each engineering school offers a half-dozen or so patterns with essentially the same skimpy wool content. Sales appeal is in the color of the shoddy, denoted by the hopeful adjectives chemical, civil and the like. This article is argument for an all-wool product made by slow, careful handwork. Bluntly it proposes a thorough four-year undergraduate drill in fundamental science and general engineering empirics, leavened by continuing study of the third of the engineer's troubles: *Man*.

It is not contended that existing methods of engineering education have failed to start men on the path to successful engineering practice (too many of you have started that way); rather, social conditions and the bounds of knowledge have changed tremendously, and corresponding alterations in the pattern of engineering education are overdue.

We'll Teach the Specifics

The first part of this contention is illustrated by excerpts from a letter received recently from an officer of one of the largest corporations:

"We are interested in employing two or three outstanding young engineers to be placed on a special training program to develop them as design and construction engineers. . . .

"We propose to put these men on a four-month indoctrination and orientation course after which they would be given job-training assignments for a period that will vary from about six months to about a year and a half depending upon the aptitudes, abilities and intelligence of the candidates. . . .

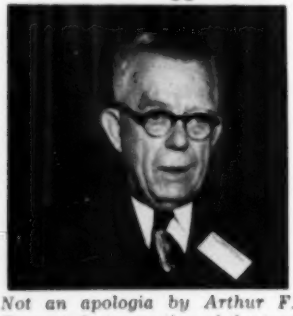
"I am not too fussy about what kind of engineers the men might be insofar as academic courses are concerned. They could be . . . in almost any engineering classification. . . . We can furnish the additional training beyond the academic fundamentals.

"The starting rate for these jobs would be $326 per month. . . ."

This letter is not unique; rather it is representative of a practice that has become common. It is industry's enforced response to the general refusal by young graduates to submit to union domination in order to gain operating experience at the labor level. The message to engineering schoolteachers is plain: You teach the fundamentals; we'll teach our practice and pay the graduate to learn it.

The letter means to the student that time spent in school studying the specific practices of particular industries is waste compounded. The school can't give the equivalent of what industry teaches, wherefore industry will still demand apprenticeship. The student must pay for the specific instruction at school instead of being paid to take it later. And time-consuming specifics crowd out drill in basic scientific and technical subjects as well as liberal arts.

What makes Taggart tick:



Not an apologia by Arthur F. Taggart, but a portion of the text lifted out by the editor because it gives a picture of the man behind the article and therefore a better understanding of it.

"My undergraduate course contained no formal studies of mankind and the barest minimum of basic science and general engineering. Geology and Mining it was called and that is what it was. My graduate year was law. I never had an opportunity to test the benefit of my specifics, because I switched fields again immediately after a semester as a special student in ore dressing. And in better than 30 years of consulting practice no one ever paid me a thin dime for doing or telling them how to do anything that was written out in a technical textbook or handbook. The subjects I have had to learn in order to collect, if not to earn, my fees have been the things I have recommended herein for study.

I am not taking the position that those undergraduate years were wasted from my standpoint. Far from it. Because I had outstanding teachers in mathematics and mechanics who gave me my introduction to the method of science teaching which I have recommended herein. I had a geology teacher who made the crust of the earth a book to challenge me every

What the letter should say to school finance committees is: Why do colleges persist in teaching outmoded descriptions of field practices when industry is teaching current practices to graduates at its own expense?

If this proposal is adopted it would mean that departmental lines in engineering school would be drawn at the graduate level, and that departmental instruction would be directed toward training specialists in technical research and development. This is the proper field of work for the engineering specialists on the campus since the primary emphasis is on joint student-faculty application of scientific and engineering method to the discovery and improvement of technological efficiency therethrough. In undergraduate school the emphasis is, or should be, about equally divided between helping students over the transition from adolescence to manhood, and the inculcation of good work habits.

The Concept Stated

Argument on the academic worth of the proposal may be both definitely pointed and conveniently guided by definition of its goal, thus: *Engineering is the technical direction of profit-seeking control of the phenomena of inanimate nature.* The key ideas are *natural phenomena, control,* and *direction.* The limitation implied in *inanimate* should not be taken too strictly: wheat and corn are inanimate; that they may be marketed as milk or hogs does not remove profitable grain production from the engineering field. *Technical* is meant to limit only to the extent that it excludes the purely financial activities of management. But *profit-seeking* denotes definite exclusion of such technological controls as those involved in much of the public work of the present socialistic regime, wherein regard for cost is either entirely lacking or the goal is the highest cost attainable, according to the number of votes to be bought and their prevailing prices.

The knowledges and skills necessary to practice engineering thus defined clearly cumulate in difficulty in the order of the key words. *Natural phenomena,* so far as they are known, are matters of recorded fact. *Control* requires not only knowledge of these facts and their relationships but also the use of mechanical and/or chemical tools in the hands of coworkers. *Direction* involves leadership.

Chemistry and physics comprise the basic record of all that is known in definite and certainly determinate form about natural phenomena. Mathematics is the tool of coordination and quantification of such facts. An engineer must work effectively in all of these fields and his undergraduate training should go far toward preparing him to do so.

Science—the Key

The aims and methods of teachers are the solution to the apparent dilemma posed by the existence of a body of knowledge, unassimilable in its entirety, which must be used at random in daily engineering practice. What must be taught is not what is already in the books, but how to find and use it. Practically, that boils down to initial selection by teachers of the relatively few broad, basic principles upon which they depend in their own thinking; subsequent harping and hammering away on these by classroom and laboratory quizzing coupled with problem homework based on self-study of text assignments; careful, critical reading of laboratory reports and other homework followed by written comment that once again emphasizes the basic principles, all continued until the class begins to recognize their breadth and bearings and to learn the rudiments of their application. By this time it will probably be the end of the term and both teacher and class will be completely disgusted with the subject and each other. But the men that a teacher can honestly pass will have the beginnings of a working knowledge of the subject. That is to say, they will know the kinds of books to go to, how to study them with a certain amount of discrimination and economy of effort, and will have had practice under criticism on how to use what they learn for the solution of problems. Actually they should know what the fundamentals of the subject are as well as the instructor does, though lacking his facility in application.

If working knowledge of basic science is accepted as a requisite for engineering practice, it is ridiculous to attempt to cram science study into the freshman and sophomore years as is now commonly done. Use and re-use of scientific concepts are essential to development of any facility in their application. Such practice is normally more productive under the critical eye of a sympathetic instructor than in the plant of the most understanding employer, even admitting the educational value of the economic urge in the latter environment. Hence continuation of study of all three sciences throughout the undergraduate years is urged.

time I have gone into new territory since, and who thereby awoke an interest in the ever changing aspects of familiar surroundings.

Various other instructors who were also teachers voiced admonitions at embarrassingly appropriate times that have stood me in good stead since. For example: Slide-rule answers will average more accurate than most engineering data set up on the rule, if they check mental estimates of magnitude made during the setting. Sundays and holidays were made to get caught up in. Recite on your feet without er's and uh's. When you have spent a lot of time composing a piece of written work, make a fair copy for presentation. Don't ask damn' fool questions. (That one frequently came from the instructor who voiced it in the form of a pitying smile unaccompanied by words.) Use the dictionary. Don't argue about what would happen in the laboratory; try it and see. (Cautiously, of course.) Arithmetical errors produce errors of fact. Take your medicine without bellyaching. Don't quit till the job is finished. Don't believe everything you read in a textbook. Read the question before you start the answer. What you learn yourself you know. . . .

There's nothing particularly original about that list; little that a man won't learn by himself in time; little, indeed, that he won't relearn several times in any event. Yet I have been well repaid because I was started on the learning early. On the other hand, I know that I could have done more work in my time with less labor if my scholastic efforts had been directed consistently to the subjects which I have had to learn the hard way since, and which I am sure I would have learned better under informed direction."

In addition to the pure sciences, industry uses a large body of empirical rules earlier designated herein engineering empirics. They comprise the generalizations of experience about materials and energy and their coactions that have not yet reached the point of definiteness and certitude that permits compositions to be given by precise chemical formulae, properties to be stated in scientific units, and actions to be set down in equations that balance dimensionally without coefficients of complex and unknown character. They are important. They are of the essence of all engineering procedure. They may be grouped under the titles: *materials, stationary structures, energy transformation, machines, process elements, approximation.*

Enter the Variables

Materials, as an engineering subject, comprises all nonliving matter, natural and synthetic: wood and the chemical polymers; natural rocks and concrete; metals and their alloys. They are flammable and the reverse, strong and weak, brittle and tough, corrosive and corrosion resistant, conductors and insulators, massive and fibrous, cheap or expensive, long-lasting or short-lived, plentiful or rare, in bewildering combinations. No engineer escapes choice among them. No engineer can or should attempt to learn all about them. But every engineer must learn to use effectively the pertinent known facts about those that he may need at a given time.

Making sure that *stationary structures* remain fixed is a concern of every engineer. For they are not only bridges and dams, but boiler tubes and vacuum evaporators, machine foundations and mine pillars, transmission towers and smelter stacks, roads and roofs and bleacher seats. The essential knowledge here is not the detail of complicated design but the principles that underlie devising and formulating reasonably adequate checks to be applied before lives and money are committed to operation.

Nothing that an engineer does, not excluding dreaming in his office chair, but involves *energy transformation.* Ideal expression of its laws is the subject matter of scientific thermodynamics. But practice contains no exact counterparts. Hence every control that the engineer imposes on nature requires empirical approximation of the energy relationships. The methods of approximation differ in detail but the underlying principle of energy balance is always controlling, and empiricism is confined to quantification of the elements of input and output.

Machines are man's contrivances to lessen his physical and mental labor and/or to increase the results of such labor. They are the principal direct tools in engineering control. They are essentially multipliers of force or velocity, whence the laws of physics give a good start on their analysis. Empiricism enters with consideration of the effects of indeterminates like friction, vibration and shock in mechanical machines, and of equivalent phenomena in electrical counterparts. A considerable amount of rationalization has been accomplished, the elements and bases of which should, by proper presentation, be made comprehensible to and usable by every engineering student.

Processes rank with machines as tools of engineering control. At first blush they would seem to constitute an unassimilable multitude. That is not the fact. Every technical process is a complex that is reducible into simpler elements. If this reduction is carried far enough, each element comprises either a physical action or a chemical reaction. Once these are isolated the appropriate scientific laws become available to facilitate understanding and control.

Eliminating Lost Motion

Machines and processes in industry change rapidly. They are often outmoded before their descriptions reach the textbooks, owing to time lags up to several years caused jointly by industry secrecy, and subsequent delay in the necessary conjunction among subject matter, author and publisher. It follows that classroom study of book-described detail is a waste of time. But the methods of analysis for segregating the operating elements of machines and processes generally, and relating these to basic scientific principles are the essence of engineering investigation. Teaching such methods should be the primary aim of instruction in these fields.

Approximation embraces the complementary operations of statistical analysis and resulting quality control. It is the beginning of reduction of engineering experience to mathematical routine. It is the application of the laws of probability to the repetitive operations of industrial practice. It seeks to substitute actuarial estimation for guesswork in prediction of quality, and to establish reliable pointers toward unknown causes of present and even of impending trouble. It doesn't supersede imagination in engineering but it reduces the necessity for gambling. Successfully applied, even in its present experimental state, it makes more time available to the plant engineer for creative thinking as opposed to recurrent emergency trouble-shooting. It is a partial but by no means total substitute for "years of experience."

Making Engineers

Performances in terms of yields, capacities, efficiencies and costs are counters in the techniques of approximation. They have an even more important function as the distinguishing feature between engineering and scientific viewpoints. Science is not concerned with them; in engineering they determine whether a scientific fact is a presently available industrial building block. Successful permanent inoculation of his students with the latter attitude while inculcating a healthy respect for science as always underlying and often leading in engineering development is one of the difficult tasks of an engineering teacher.

Instruction in engineering empirics should parallel the science instruction, each consciously supplementing the other. Unorganized study of materials and chemical processes is already part of elementary chemistry; elementary physics introduces concepts of stationary structures, machines and mechanical processes; energy transformation runs through both. Formalized study of the use of approximation when practical situations replace the controlled laboratory conditions of pure science should be started in sophomore year. It can be profitably foreshadowed by instructor comment in the elementary courses when losses in friction, heat transfer, electrical resistance and the like are commonly overlooked.

Direction and *control* are cause and effect in engineering. The relationship is based on mental contact between the engineer as director and those who act on the direction and whose muscular efforts, either directly or multiplied by machines, impose the desired control. Hence the initial step in directed control is always a human act; which is to say that its

character and effectiveness are determined by skill, but conditioned by emotion. It follows that the best possible understanding by the director of the consequential relationships between emotions and acts is a prerequisite to successful engineering practice.

Study of Man Vital

Pope once said: "the proper study of mankind is man." That implies laboratory approach to a large subject. There is not time for it in engineering school. Hence the school reverses Pope's formula and prescribes study of the record of mankind to teach the beginnings of a workable understanding of man. This record may be classified broadly into studies of groups and of individuals; of past and current happenings; the analytic and the synthetic; the critical and the emotional. All have their place. History is, in the main, the study of group reactions in the past to various stimuli, mainly economic. Politics is the study of history in the making. Economics is the study of wealth, defined as the means of satisfying man's material desires. Business law and practices are the offspring of the last two. Literature, in the sense of the organized study herein discussed, comprises the reactions of individual authors to the conditions of man's life, expressed analytically and critically in essay form, or synthetically and emotionally as fiction. Introductory courses in astronomy, geology and biology, defining respectively man's place in the universe, the earth, and among the living matter that surrounds him will aid tremendously in student understanding and appreciation.

Engineering faculties have come slowly and with much backing and filling to a reluctant admission into their curricula of dabs of the more directly utilitarian of these subjects. The plea herein is to make the overall time allotment for studies of mankind coequal with those for science and technological empirics, and of this allotment to give the major share to literature. For literature is a culture medium second only to life for the growth of the engineer as a man. It pictures in myriad ways the infinite variety of mankind in infinite combinations with its environment. It epitomizes the groups of history and politics as easily recognized individuals swayed by a complex of emotions among which the greed implicit in modern economics analysis is far from predominant. Its normal effect is to engender understanding and sympathy.

Design for Leadership

The director that should be molded is one who can point the thoughts and cooperative actions of his subordinates toward the technological control that he seeks. If sympathy and enthusiasm for that end are likewise engendered, the direction takes on the character of leadership and the possibilities of success are immeasurably increased. Would-be directors make charts of chains of command with lines and blocks of different kinds, shapes and colors, all of which would seem to overlook the simple infallible law that no chain is stronger than its weakest link. Others write books and offer courses on the technique of direction which trusting folk who will may patronize. For the critical it is worthy of note that neither kind of effort ever seems to emanate from directors of proven eminence, and that eminence is rarely gained by people who busy themselves in such activities. The common attributes of a successful director—which in engineering connotes a successful engineer—are knowledge, imagination, honesty and sympathy, and finally that courage to move where imagination tempered by knowledge beckons, which is called initiative. Command of the prevailing language is a must and fluency is highly desirable.

The necessary command of language is, both by necessity and logic, a development parallel to that in other studies. It requires a vocabulary large enough to describe and express all of the physical objects, human emotions, and the actions and reactions of both animate and inanimate things with which the engineer must deal. There must be accurate comprehension of the customary rules of grammar and simple rhetoric—without, perhaps, the ability to quote any of them. Only so will the sequence of words that cross the engineer's desk in reports and orders, outgoing and incoming, receive the understanding necessary. Command of this kind can only be initiated in the usual short course in the native language to which engineering students are exposed. The most that the instructor here can do is to prescribe frequent written exercises and to criticize them carefully and suggest means to overcome the defects. Thereafter all instructors should pick up the burden by making language one of their grading bases. Vocabulary grows with knowledge; knowledge of grammatical usages and simple sentence structure with criticized practice; understanding of subject matter with academic progress; something to say follows; and care in saying it can be enforced by scholastic penalties. It is one teacher's observation that an A for content degraded to C for poor presentation has more beneficial effect than hours of exhortation.

Naming the Curriculum

In recognition of its simple, straightforward purpose this proposed course might well be called Pre-engineering. That name would also be consistent with present-day industrial handling of young engineering-school graduates. But young men and their parents being what they are, the modest "Pre-" lacks sales appeal, wherefore the title *General Engineering* is suggested as properly descriptive of both the proposed course of study and its possible ultimate goal.

Education is a field in which logical argument based upon exact data is impossible because comparable data are unavailable. The students in a class vary among themselves in capacity, aptitude and preparation. Class performance varies from week to week according to demands in other directions and from year to year both randomly and in response to prevailing emotional conditions, e.g., impending military service. Instructors are at least equally variable, not only in individual abilities and their ups and downs of performance, but in their judgments of student performances both with time and among themselves. Opportunity for graduates differs tremendously with time, location, family associates and chance. Hence the reader will like this proposal or not as the case may be.

As a concluding paragraph I want to set down some convictions that apply equally to the proposed and to existing curricula. I am certain that the training in self-study of books while stripping the subject matter taught in class down to the barest core of absolute fundamentals is the most important thing undergraduate teachers of science and the empirics can do to help their students to solve their future technical problems. I believe that imagination is curiosity's daughter and that persistent, sympathetic quizzing by instructors will help to re-

awaken in college students something like the what's-this-what's-that attitude of kindergarten days, but now directed inward, so that these men may say later, after Kipling:

"I keep six honest serving men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who."

I urge that good, old-fashioned morals be preached openly and fearlessly whenever and wherever the frequent need arises. Some years ago many business offices carried a placard that read: "Live each day so that you can look every damn' man in the face and tell him to go to hell." It has largely disappeared, perhaps for its blatancy, but I'd like to see its spirit developing in every classroom. It appeals to courage, which every man craves and which an engineer must have to go ahead, as he is forced to at times, on inadequate facts. It is a strong antidote to the cowardice that underlies student cheating and the concomitant lying, and it works against the active or acquiescent disowning that constitutes disloyalty. It encompasses the Golden Rule, which is the essence of successful living and working with people.

Books for Engineers

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

Geology, by O. D. Von Engeln and Kenneth E. Caster, McGraw Hill Book Co., Inc., $7.00, 730 pp., 1952.—The authors desired to write a book which would supplement the work of the teacher. The effort presents the facts of historical geology as an outgrowth of the understanding of physical geology—a method in keeping with the fundamental law of geology that "present agencies and forces, acting through enormous time, have shaped the world as we see it—the law of uniformitarianism." Narrative continuity is maintained throughout the text. Each historical geology period is made distinctive, provided with an identity, and shown to have particular characteristics.

Elementary Heat Power, second edition, by Harry L. Solberg, Orville C. Cromer, and Albert R. Spalding. John Wiley & Sons, 1952. $6.50, 624 pp.—The authors attempt to develop an understanding of the functions, principles of construction, and actual performance of heat-power machinery as a preliminary to the study of engineering thermodynamics. Matter and energy, fuels, and combustion are considered first, followed by chapters on internal combustion engines, fuel burning equipment, and steam engineering and utilizing installations. Pumps, compressors, gas turbines and refrigeration are also dealt with.

The Economic Design of Rectangular Reinforced Concrete Sections, by T. P. O'Sullivan. Pitman Publishing Corp., 1950. $2.75, 76 pp.—The book deals with factors arising in the design of rectangular reinforced concrete sections subjected to direct compression, direct tension, and bending movement. A detailed analysis of these conditions is made, leading to design charts for various conditions. The optimum arrangement for economy is established in every case. An appendix shows how simply derived tables may be set up for the solution of sway frames direct from strain energy considerations.

Red Metal, The Calumet and Hecla Story, by C. Harry Benedict. University of Michigan Press, 1952. $4.00, 257 pp.—The book traces the fortunes and misfortunes of the men involved in the 85 years of development and production of the largest of the Michigan Upper Peninsula copper mines. It brings to life the early missionaries who first went into the territory, the adventurous but realistic Boston financiers, the engineers, geologists and entrepreneurs, in an understandable relationship. It gives the background of one of the richest and oldest mines in the U. S., Calumet and Hecla. The story deals with the problems of the present day company, arising out of its vast diversification.

Geologie Von Mittel Europa, by Paul Dorn, 1951. E. Schweizerbart'sche Verlagsbuchlandlung. DM 48.80, 474 pp.—The book incorporates a large amount of new information and data on stratigraphy of local regions which has appeared in the last 15 years in its treatment of the geology of central Europe. The detailed descriptions are supplemented by numerous charts, profiles, and other drawings. A pocket on the back cover contains a colored geologic map and 11 large stratigraphic tables.

Industrial High Vacuum, by J. R. Davy. Pitman Publishing Corp., 1951. $5.50, 243 pp.—The book deals with the design and manipulation of vacuum installations and gives sufficient basic theory for an understanding of the principles involved. The author has aimed the work at both engineer and physicist. Chapters are included on the application of the plant to industrial purposes, covering the major uses, methods of handling, and control of the products. Brief consideration is given to numerous special topics, such as vacuum metallurgy and vacuum dehydration.

Standard Methods for Testing Petroleum and Its Products, 12th edition. Institute of Petroleum, London, 1952. 40s, 727 pp.—More than 130 test methods, adopted or tentative, are described in the book, which corresponds to the similar ASTM publication in the U. S. Test methods cover a wide range; acidity, carbon residue, distillation processes, cloud and pour points, knock ratings, viscosity, and special tests such as the one for determination of zinc in lubricating oil.

Modern Chemical Processes, Volume II. Reinhold Publishing Corp., 1952. $5.00, 299 pp.—The book is a continuation of the series started in 1950, and contains 24 special articles describing chemical plant processes which were published in *Industrial and Engineering Chemistry* during 1950 and 1951. Some of the processes covered are sulphur mining, chemicals from fats, cyanides from the coke oven, and paper and pulp production. Background, plant installation, process and operation, economics, and personnel are dealt with. Flow charts and bibliographies are included.

Mechanics and Properties of Matter, by Reginald J. Stephenson. John Wiley & Sons, 1952. $6.00, 371 pp.—Stress is placed on the physical concepts involved in mechanics while presenting the mathematical procedures involved. The importance of the concepts to the whole field of physics is demonstrated. Vectors and simplified vector analysis are used throughout the book to familiarize the student with their use. Illustrative problems are contained in the text and practice problems accompany each chapter.

An Outline of Metallurgical Practice, second edition, by Carle R. Hayward. D. Van Nostrand Co., Inc., 1952. $10.00, 728 pp.—This new edition of a basic reference work and textbook covers nearly all metals and metallurgical practices from mine to finished product. Progress in the industry dictated that several sections be rewritten. Recent developments are treated in additional sections. Increased importance of uranium and titanium necessitated inclusion of brief chapters on these metals. The book contains more than 400 illustrations, about one-third of which are entirely new.

Development and Operation Of Sulphur Deposits in The Louisiana Marshes

by Z. W. Bartlett, C. O. Lee, and R. H. Feierabend

DESPITE the fact that American brimstone production has increased 2½ times since the prewar period 1935–1939, the demand for sulphur exceeds the supply. To alleviate this situation efforts are being made to increase the production of sulphur and bring the shortage to an end. The most important developments are being undertaken on the Gulf Coast. One new brimstone mine has been put into operation and three others are being developed. These projects are expected to account for a large part of the additional sulphur production now anticipated for the free world.[1, 2]

Except for a small amount of byproduct sulphur from sour natural gas and refinery gases, American brimstone is produced by the same process devised by Frasch 60 years ago, consisting essentially of the injection of superheated water at about 325°F into sulphur-bearing formations through wells which are drilled from the surface by standard oilfield methods. Sulphur deposits vary in depth from a few hundred feet to 2500 ft from the surface; in a typical deposit the sulphur occurs as crystalline aggregates in porous limestone and gypsum in concentrations varying from 5 to 40 pct, the thickness of the formation ranging from a few feet to several hundred.[3] The deposits are usually surrounded by formations impermeable to the flow of hot water, the top and sides being enclosed by impermeable sediments and the bottom by dense impermeable anhydrite. As the hot water leaves the well bore, it percolates through the formation and transmits its heat to the rock and sulphur. When the sulphur reaches 240°F it melts, separates from the rock, and flows through the hot channels downward to the bottom of the well. Here it is freed from incoming water and from formation water, which saturates the porous rock, by gravity separation, liquid sulphur being 1.8 times as heavy as water. It then is pumped to the surface in a relatively pure state, 99.5 pct or better. Chief contaminants are organic impurities, such as petroleum residues, which are soluble in sulphur and tend to discolor it.[4]

Sixteen deposits of commercial magnitude have been discovered in the Gulf Coast area. Five of these deposits have been depleted and abandoned with production totalling more than 26,886,000 tons. Eight properties are operating and have produced 65,875,000 tons to Jan. 1, 1952, for a total Frasch-type production of 92,761,000 tons. Three new deposits are under development. Aforementioned deposits are listed in Table I.

Each of these deposits has been found in the caprock overlying shallow intrusive salt plugs or domes and buried in several hundred to as much as 2500 ft of sediments. All salt domes do not contain sulphur; only 16 sulphur deposits have been found in a total of 231 salt domes which are known to exist in the Gulf Coastal states of Texas, Louisiana, Mississippi, and Alabama. Ten of the salt domes lie in the Gulf of Mexico offshore from the Texas and Louisiana coasts. Additional offshore domes may be found, but their value as a sulphur potential is questionable owing to the great hazard and high cost that can be visualized at these exposed locations where depths of water reach 50 ft.

Marsh operations of Freeport Sulphur Co. are in the southeast section of Louisiana. In general, the country is low, flat, relatively uninhabited marshland broken by many shallow lakes and bayous which extend for irregular distances inland. Geologically, the coastal area is of sedimentary origin, having been built up gradually under the sea by deposition of material carried down by large streams to their deltas. Offshore bars were formed enclosing

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Discussion on this paper, TP 3363H, may be sent (2 copies) to AIME before Sept. 30, 1952. Manuscript, March 18, 1952. New York Meeting, February 1952.

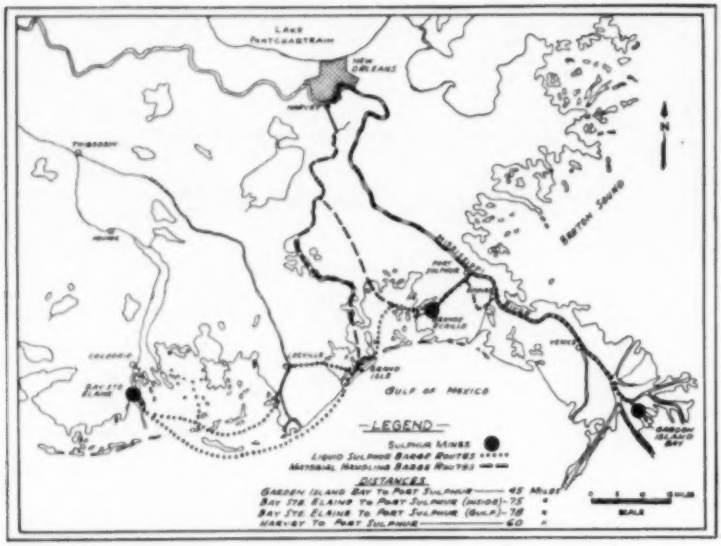

Fig. 1—Sulphur mines in the Louisiana marshes under development and operation by Freeport Sulphur Co.

long narrow lagoons connected to the open sea by tidal inlets.[3] No truly solid sediments exist near the surface, and foundations for all structures of a permanent nature or of substantial size and weight must be supported by piling. In this region mosquitoes, gnats, and deer flies abound. The salt marshes produce muskrat, while fresh water marshes have both alligators and water moccasins.

The first sulphur mining venture in this area, where many vexing problems had to be overcome, was in 1933 when Freeport Sulphur Co. started development of the Grande Ecaille mine. The location of this mine, shown in Fig. 1, is 10 miles southwest of the right descending bank of the Mississippi River approximately 45 miles below the city of New Orleans. Within the last year Freeport has announced plans to build mining facilities at Bay Ste. Elaine dome and Garden Island Bay dome, both of which are even less favorably located. Bay Ste. Elaine is near the open Gulf about 35 miles southeast of Houma, La., and Garden Island Bay is at the extreme southeastern tip of Louisiana near the mouth of the river.

Table I. Sulphur Deposits of Commercial Significance Found in the Gulf Coast Area

Deposit	Producer	Dates of Operation	Approximate Production
Sulphur, La.	Union	1895-1924	9,412,000
Bryanmound, Tex.	Freeport	1913-1935	5,001,000
Gulf, Tex.	Texas Gulf	1919-1936	11,805,000
Hoskins Mound, Tex.	Freeport	1923 to date	10,149,000
Palangana, Tex.	Duval	1928-1935	237,000
Boling Dome, Tex.	Duval	1935-1940	571,000
Boling Dome, Tex.	Texas Gulf	1929 to date	36,327,000
Long Point, Tex.	Texas Gulf	1930-1938	402,000
Long Point, Tex.	Jefferson Lake	1946 to date	990,000
Lake Peigneur, La.	Jefferson Lake	1932-1936	431,000
Grande Ecaille, La.	Freeport	1933 to date	11,970,000
Clemens, Tex.	Jefferson Lake	1937 to date	2,104,000
Orchard, Tex.	Duval	1938 to date	2,611,000
Moss Bluff, Tex.	Texas Gulf	1948 to date	712,000
Starks, La.	Jefferson Lake	1951 to date	39,000
Spindletop, Tex.	Texas Gulf	Start 1952	
Bay Ste. Elaine, La.	Freeport	Start late 1952	
Garden Island, La.	Freeport	Start late 1953	

Prospecting

The growth of geophysical methods of prospecting since 1924 has played an important part in prospecting and locating salt dome structures. The reliability and value of geophysics in the petroleum industry were quickly demonstrated,[4] and the entire Gulf coast area has been surveyed repeatedly. Reflection seismograph and gravity meter surveys first are made of large areas. On indication of a favorable structure, torsion balance surveys, now replaced by gravity meter, are made to secure more detailed information on size, depth, and configuration of the caprock area. The ultimate check is drilling.

The nature of the formations overlying the domes and the variable depth and character of the caprock materials dictate the use of relatively heavy drilling equipment except under ideal conditions. Accordingly, conventional shallow oilfield rotary drilling equipment is used. In the case of marsh operations, drilling machinery and equipment are mounted on barges identical except in size and capacity to units which the oil industry uses for marsh drilling work. Freeport Sulphur Co. recently built two drilling barges, capable of drilling to 3000 ft, at a cost of $250,000 each, see Fig. 2. The cost of prospecting in the marshes is considerably higher than in "hard ground" country. Prospecting two domes in south Louisiana cost approximately $800,000 for 20 holes, or $40,000 per hole. On a footage basis, this is about $17.00 per ft, almost double the rate for drilling similar domes on land.

Until the advent of oilfield-type diamond coring equipment within the past few years, accurate sampling of sulphur formations for reserve estimates

Fig. 2—A Freeport Sulphur Co. floating drilling rig at Garden Island Bay, site of one of the company's new mines in the Louisiana swamplands. These rigs, which cost $250,000 each, can drill to 3000 ft.

was difficult because of loss of fluid returns in porous formations and because of the soft, friable nature of sulphur. Now, with diamond coring equipment, 90 to 100 pct recovery can be expected from cores 3½ in. to 4⅜ in. in diam. The bits cut holes 6⅛ in. and 7⅞ in., respectively, and the cost for bit heads ranges from $1.00 to $1.25 per linear ft of hole.

Terrain and Foundation Conditions

In the vicinity of Grande Ecaille the surface of the marsh consists of salt grass and decayed vegetable matter at elevations of 1 to 2 ft above mean Gulf level. The marsh is underlain by 5 or 6 ft of humus, 40 ft of very soft clay, 20 ft of soft clay, and medium stiff clay thereafter to a depth of 130 ft. Some thin sand streaks and lenses are present, but these have negligible supporting value. Seventy-five foot pine piling will support 8 tons per pile, this value being developed in skin friction alone. Sulphur storage bins, which impose an area load of about 2500 lb per sq ft on 60 to 75-ft wood piling, have subsided 3 to 5 ft because of compression of the medium stiff clay below the pile tips. The power plant, see Fig. 3, supported by 75-ft piling with a semi-rigid foundation has subsided 6 in. under an area load of 1200 lb per sq ft. More than 100,000 piles have been driven at the Grande Ecaille mine.

Marshes in the Garden Island Bay area are more recent than those at Grande Ecaille and are subject to overflow by fresh water from Mississippi River distributaries. Natural banks at the edges of the distributaries are fairly firm and reach elevations of 2 to 4 ft above mean Gulf level for widths of 50 to 100 ft. The intervening marshes consist of very soft clay at elevations ranging from 1 ft above to 3 ft below mean Gulf level, covered with cane, grass, and water hyacinths. The entire area is underlain by very soft clay to a depth of 50 ft and soft clay to a depth of 150 ft. Soil analyses indicate that a 75-ft wood pile will support 7 tons by skin friction and that an area load of 1200 lb per sq ft supported on 75-ft wood piling with a rigid foundation cap will subside approximately 9 in. Further studies have revealed that the present rate of geological subsidence of this area is 1 ft in 20 years and that mean Gulf level is rising 3 in. each 20 years.[4]

Marshes in the Bay Ste. Elaine are similar to those at Grande Ecaille, and soil analyses indicate about the same supporting values.

Water Supply

An adequate supply of suitable water is a fundamental requisite of the Frasch Process. Tide water is available at all marsh domes, but the high salinity of this water makes it objectionable for use in a conventional Frasch Process plant. For the Grande Ecaille mine the only source of fresh water is the Mississippi River 10 miles distant. Normal river water contains 1.6 grains salt per gal, 28 ppm as NaCl, and 6.9 grains total hardness, 118 ppm as $CaCO_3$. During late summer and early fall, however, the flow in the river is reduced to such an extent that sea water invasions occur upstream along the bottom of the river. This phenomenon occurs each year, but its duration and the upstream distance of the invasion depend on the amount and distribution of rainfall within the watersheds of the river and its tributaries. At Port Sulphur, which is 55 miles upstream from the mouth of the river, contaminations by sea water occur each year, and to mitigate the effect of the contamination a 240,000,000-gal earthen reservoir has been provided.

The location of the Garden Island Bay mine, which is only 3 miles above the mouth of one of the distributaries of the river, greatly intensified the water supply problem for a fresh water plant. A study of the river flow and salinities indicated that the period of poor quality would be much longer than at Port Sulphur. These predictions left no alternative but to provide a reservoir for approximately 6 months' storage of fresh water if seasonal crippling interferences to the operation of a fresh water plant were to be avoided. The amount of water for mining purposes plus that lost by evaporation, transpiration, and seepage requires a 600-acre reservoir with an available capacity of 600,000,000 gal. Construction of suitable reservoir levees with the soft material at the site presents a difficult problem in itself. To construct levees 10 ft in height, it is estimated that five lifts of dirt will be required with a period of soil consolidation between each lift. The base of the levee will be about 180 ft in width. Time required for construction will be about 20 months,[4] and levee construction costs alone are estimated to be $250,000.

At the Bay Ste. Elaine mine the only source of

Fig. 3—Freeport Sulphur's power plant at Grand Ecaille, La., mine, which heats 6.5 million gal per day. The plant is constructed on 5000 piles. Both compressed air and hot and cold water go to the field via the pipes in the foreground.

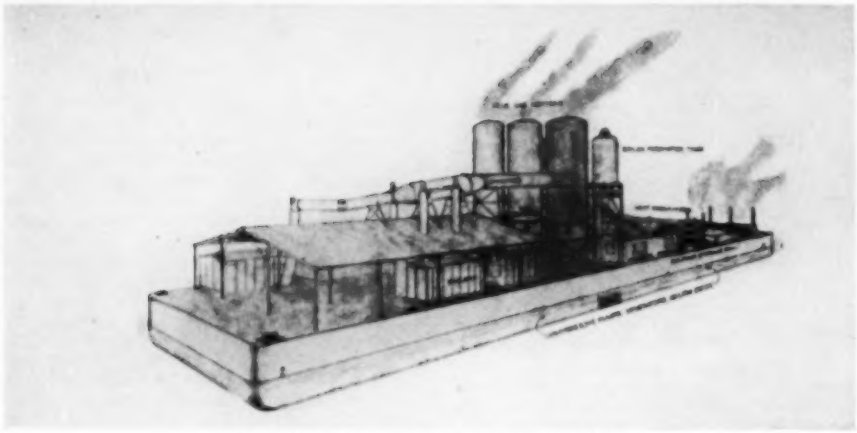

Fig. 4—Mining barge for Bay Ste. Elaine sulphur mine.

fresh water is approximately 35 miles distant. The cost of pipe lines and pumping stations for this distance would be prohibitively high, especially since the deposit is too small to justify a large capital investment. To solve this problem, Freeport Sulphur Co. has developed a process in which brackish water or sea water, which surrounds the property, can be heated to mining temperatures. This process is described in the following paragraphs.

Heating Plants

The heating plants used in all existing Gulf Coast sulphur mines are almost identical in their flowsheet and vary chiefly in size. A number of papers have been published which describe these plants; therefore only a brief description is included below.

The Grande Ecaille plant was built in 1933 with a capacity of 2,800,000 gal of hot water per day but has subsequently been expanded[7] so that the output now averages 6,470,000 gal per day of 325°F water. The plant now includes six 50,000 gal per hr hot process water treating units. The boilers are of the four-drum Stirling type. Each of the six has a capacity of 75,000 lb steam (200 psig) per hr, and each of two others has a capacity of 85,000 lb steam (400 psig) per hr. Capacity of power generation amounts to 4250 KW, which is furnished by three 750-kw turbo-generators and one 200-kw unit. Compressed air for pumping sulphur wells is furnished by four 700-cfm (800 psig) air compressors. Four heat reclaimers recover heat from the boiler flue gases and contribute to the high overall plant efficiency, which averages 85 pct. All pumps which handle the cold and hot water in the plant are of the centrifugal type and driven by steam turbines. Foundation for this plant,[8] which was very costly, consists of over 5000 piles 75 ft long driven on 2-ft 8-in. centers. The pilings were cut off at ground level and capped by a concrete mat 2 ft 6 in. thick with extra heavy piers closely spaced to support the heavy plant floor, which was elevated to about 12 ft above mean Gulf level.

The flowsheet of the Garden Island Bay plant is similar to that of Grande Ecaille. The plant, which is now under construction, is designed to deliver an average of 2,700,000 gal of 325°F water per day with an overall plant efficiency approaching 90 pct. The plant will include three 50,000 gal per hr hot process water-treating units, four water-wall Integral Furnace-type boilers each having a capacity of 60,000 lb of steam (425 psig) per hr, two 800-kw turbo-generators, three 500-cfm (800 psig) air compressors, four flue gas heat reclaimers, and turbine-driven centrifugal pumps for handling water. Foundations for this plant will be similar to that of Grande Ecaille but will cost considerably more per ton of supported load, because the supporting power of the subsoil is even less than that at Grande Ecaille.

The Bay Ste. Elaine deposit introduced additional problems over those encountered at Grande Ecaille and Garden Island Bay. One of these problems was the small size of the orebody which would not support a large capital investment. This prompted investigation of a portable type of plant that could be moved to other locations if the venture proved unsuccessful or if the life of the property was short. Consequently, the heating plant is being constructed on a large steel barge which will be floated to the mine site and sunk into position, see Fig. 4.

Another serious problem was the lack of a source of fresh water. Fortunately this problem had been foreseen when it was realized that new brimstone sources would probably be located in tidewater areas, and research extending over the past 8 years has been conducted by Freeport. This work led to the development of a new process[9] in which bay water having a salinity as high as 1640 grains of salt per gal, 28,000 ppm, will be heated to 325°F for mining purposes instead of piping fresh water from a source 35 miles distant.

The heating of sea water for sulphur mining purposes[9] will represent the first time in history that such a process has been attempted, mainly because of the scaling and corrosive problems ordinarily expected. Scale deposited from sea water when it is heated to high temperatures is made up of two different classes: 1—the deposition of calcium and magnesium as carbonates and hydroxides owing to the decomposition of bicarbonates, and 2—the deposition of sulphate scale caused by the lowering of the solubility of calcium sulphate when the water is heated. A normal approach to eliminating scale would be to

remove all or part of the calcium and magnesium by chemical treatment. In the case of sea water, however, this would involve a very high cost because of the large amount of these elements present.

Freeport's approach to the problem was not the removal of these elements but the development of a process and equipment for heating the water in such a way that decomposition of bicarbonates is prevented. It is hoped that details of the processes which have been developed by Freeport Sulphur Co. will be the subject of a paper at a future date. Basically, the process to be used at Bay Ste. Elaine consists in heating the sea water under controlled conditions which minimize decomposition of bicarbonate and through proper controls prevent the deposition of calcium sulphate.

The corrosiveness of water having high salinities even in a cold state has been observed for a long time. In a hot state and during heating, corrosion should be excessive. Freeport has developed a process which overcomes excessive corrosion by the use of a unique apparatus. The removal of oxygen from sea water substantially reduces its corrosiveness, especially in a hot state. The removal of oxygen is accomplished in an apparatus consisting of a packed tower in which cold sea water flows downward through packing. In the upper part of the bed the water is contacted with flue gases discharged from the boilers and in the lower part of the bed with the products of combustion of natural gas burned directly into the tower. This apparatus serves several purposes. First, the temperature of the water is raised from about 75°F to 145°F and a large amount of heat reclaimed from the boiler flue gases, thereby maintaining the overall plant efficiency at 85 to 90 pct. Secondly, the water is raised to 190°F by burning fuel in the base of the tower using theoretical combustion air in a premix burner. This eliminates the heat normally supplied by boiler steam in raising the temperature from 145°F to 190°F. Third, the water is effectively de-aerated to less than 1/10 ppm of dissolved oxygen by contacting the water with the inert flue gases in the base of the tower.

Following the heating of the water to 190°F, the water is raised to 325°F by means of steam in indirect heat exchangers. Some soft sludge accumulates inside the tubs of the heat exchangers and a reduction in heat transfer rate occurs. Restoration of the heat transfer rate is accomplished by periodic flushing with steam which effectively removes the sludge from the exchangers. Although the corrosiveness of the water is reduced by de-aeration, corrosive resistant alloys are needed in the heat exchangers and small pipe fittings. In larger fittings and pipelines, cement-lined steel has been found suitable, and in well equipment a protective scale can be deposited by small and controlled injections of chemicals into the water as it enters the well head.

It is not anticipated that the new plant and process will be preferable to the conventional plant where fresh water is available. The initial plant cost is less, but the operating costs are expected to be greater.

The Bay Ste. Elaine plant is designed to deliver an average of 1,750,000 gal of 325°F water per day, 400 cfm of compressed air (500 psig), a power load of 600 kw, and miscellaneous steam for heating sulphur lines and equipment. Five water tube packaged-type boilers will be provided, each having a capacity of 30,000 lb steam, 400 psig, per hr. The sea water while passing through the flue gas heaters is heated from an average of 75°F to 190°F. High pressure centrifugal pumps then force the 190°F water through tubular heat exchangers where the latent heat of evaporation of the steam is transferred through the tube walls and into the water. The condensed steam is then re-cycled back to the boiler. In this manner, where distilled water is continuously used in the boilers, a water treating problem is eliminated and fresh water requirements are reduced to only that which leaks from the system. To make up for this loss of distilled water, an evaporator will be provided to distill either sea water or fresh water barged to the plant site. The pressure of the hot water leaving the exchangers will be sufficient to convey it through surface pipe lines and to inject it into sulphur-bearing formations. Three flue gas heaters will be provided, each being 10 ft in diam by 52 ft in height with two layers of packing. Specially designed shell and tube heat exchangers will be provided, each having three passes with alloy tubes in each pass. The boilers, see Fig. 5, operate at 400 lb psig and the steam will be expanded through prime movers, discharging at various back pressures to the exchangers. The mining barge, which is illustrated in Fig. 4, will be 40 ft wide by 200 ft long and 12 ft deep. When completed it will have a draft of about 5 ft, and after being towed to its location at Bay Ste. Elaine it will be sunk on a prepared bottom so that the final elevation of the deck of the barge will be about 6.5 ft above mean Gulf level.

Producing Operations

It is difficult to make a prediction of the rate of production from a new deposit because the productive capacity of two mines with similar facilities is seldom equal. Production varies from day to day and no area or even individual well will yield identical results. This variation of production is due primarily to the everchanging thermal conditions of the rock structure into which water or heat is injected. Many factors upon which little or no control

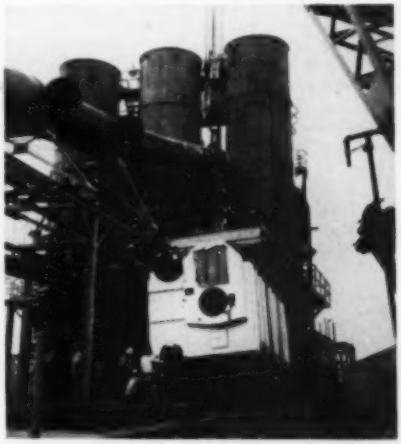

Fig. 5—One of the five boilers which will supply the Freeport Sulphur operation at Bay Ste. Elaine with 1.75 million gal of water daily is installed on a barge presently under construction. When completed it will be towed to the mine site and partially sunk on a prepared bottom.

can be exercised enter into the thermal efficiency of the individual deposits, areas, or wells. The major factors probably are the physical nature of the rock structure, reserves and concentrations of sulphur, and the rapidity of subsidence. Efforts are made to account for each of these factors in the design of surface facilities and operating procedures, but actual performance frequently dictates changes after operations have begun.

The pattern of melting is dependent on the course taken by the mining water from the point of injection. Because in most cases there is complete lack of uniformity of the formations, only generalized heat flow patterns can be predicted. Formation temperatures at the beginning of production are about 100° to 125°F. Both the sulphur and the enclosing rock must be raised above the sulphur fusion temperature. Cold formation water must be displaced and the loss of heat by conduction to overlying sediments must be supplied in order for the process to work. Permeability of the sulphur horizon and the barren caprock is usually so great that the only motivating influence which governs the flow of hot water through the rock structure is gravitational force. This force is obvious when it is realized that the incoming hot water has a density of about 0.9 compared to cold formation water at 1.01.

The consequent upflow of hot water continues until an impervious barrier is reached, or until the density of the mining water equals the density of formation water, and then lateral spreading occurs. As this takes place sulphur is being melted, the permeability and porosity of the rock is changing, and entirely new water channels may develop, sometimes favorable, but frequently detrimental. It is a known fact that extraction of sulphur takes place from the top of the deposit and progresses downward. Lateral extraction is quite limited, as indicated by the close well spacing necessary for depletion. A number of schemes have been attempted to control the extraction patterns or to overcome unfavorable channel conditions. Most successful of these has been the injection of mud[4] to block off cavities or to cause a more uniform permeability. Another method has been the use of a high density mining fluid[10] such as concentrated salt brine. Hot concentrated brine, having a density greater than formation water, initiates a downflow of heat pattern. In practice these two schemes are costly and therefore are used only when absolutely necessary.

The existence of a thick permeable barren zone atop the sulphur horizon is detrimental, as it allows the escape of water away from the melting area. It can be visualized that such a zone must be heated above the melting point of sulphur, actually forming a hot water cap, before substantial progress toward extraction can be accomplished. Experience has shown that domes of this character are high water consumers and generally low rate producers.

The thickness of the sulphur horizon and the concentration of sulphur have marked effects on the yield. Thick but lean zones cannot be expected to produce with the same ease or efficiency as rich zones of lesser thickness, even though the indicated tonnage may be equal in each case.

Subsidence

Subsidence, that is, the collapse of the rock from which sulphur has been removed, is of major importance in Frasch mining. It materially aids ultimate recovery by reducing the voids and preventing rapid escape of hot water from the producing area, and since it manifests itself at the surface in large sink holes, it influences the selection of the original plant location, operating facilities, and methods.

Because of the soft, unstable surface conditions of the marsh and the anticipated large area of surface subsidence, the plant at Grande Ecaille was located about 4000 ft away from the edge of the orebody. As a result plant subsidence has been negligible. The original well control station located near the edge of the orebody has settled almost 6 ft, and although the nearest production is 2000 ft away, this station last year settled 2½ in. Maximum subsidence amounting to 24 ft in depth has taken place over the area of greatest underground extraction. After 18 years of operations, the total volume of surface subsidence has about equaled the volume of sulphur removed from this deposit.

Hydraulic dredges are used to restore the surface to an operating level above sea level. To date over 22,000,000 cu yd of dirt have been pumped from outlying areas to refill the subsided mining area. This amount is in addition to about 8,000,000 cu yd pumped underground to fill cavities which originally existed in the deposit.

Land Mining

Grande Ecaille is a land-type operation. Initially the marshland over the orebody was filled to a height of 4 to 8 ft above sea level by hydraulic dredge. Since then the area has been partitioned by levees into smaller areas so that sections of it could be refilled while production continued on other portions. To refill an area all derricks, ramps, pipe lines, and buildings must be removed, and after refilling, drying, and consolidation requiring two or more years' time derricks, ramps, and pipe lines must be replaced before production can be resumed. This cycle is repeated several times before the area becomes depleted of sulphur, because no area can be depleted before surface subsidence extends below sea level. Several attempts have been made to continue mining with the surface below sea level, but the cost of levee maintenance and surface drainage is excessive.

All operations involving machinery must be on board roads or heavy mats. Currently there are over 5 miles of heavy board roads in service. These roads are designed to carry 30-ton moving loads, cost about $8 per ft, and last about 4 years. Conventional oilfield equipment is used for drilling wells. Material handling has been mechanized by the use of fork lift trucks, straddle trucks, mobile rubber-tired cranes, and winch tractors for skidding derricks and other heavy equipment.

Marine Mining

The small size of the Bay Ste. Elaine deposit, the unusual terrain, and the urgency of the need for increased sulphur production demanded a new type of drilling and producing operations, comparable to land mining as practiced at Grande Ecaille. Land mining, which requires surface filling, is cumbersome. A deposit such as Bay Ste. Elaine, where well life is expected to be short and surface subsidence negligible, adapts itself to a marine form of mining requiring no surface fill. Machinery will be barge-mounted instead of land-based, boats will be used instead of trucks and tractors, canals will replace roads, and all pipe lines will be supported on piling bents.

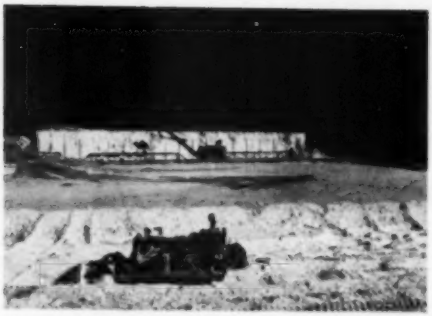

Fig. 6—A bulldozer in the foreground prepares the vat site at Grand Ecaille. A thin layer of molten sulphur is being sprayed in the center.

A similar mining system is planned for Garden Island Bay. At this mine considerable surface subsidence will no doubt occur; but since one of the distributaries of the river crosses the mining area, sedimentation from this distributary may be sufficient to replace the surface elevation lost by subsidence. However, although this and other advantages of the marine system of mining may outweigh the disadvantages, the constant exposure to winds, waves, and tides may present serious problems.

Sulphur Storage and Transportation

Bins for the storage of sulphur at most sulphur mines are built on firm ground and require no expensive foundation. Sulphur mines in marshes are severely handicapped in this respect, since the surface must first be elevated by means of a hydraulic fill because of the low elevation. At Grande Ecaille the storage area was filled to an elevation about 10 ft above mean Gulf level. After the fill became consolidated, 17,000 pilings 60 to 75 ft in length were driven on 4-ft 3-in. centers. These pilings have supported bins of sulphur 20 ft in height, but in 18 years have subsided 5 ft because of compression of the soil below the pile tips. The working storage of the bins, or vats, is about 160,000 long tons, see Fig. 6.

Since the terrain and foundation conditions are somewhat better at Port Sulphur[11] than at Garden Island Bay and Bay Ste. Elaine and since shiploading facilities have already been installed at Port Sulphur, it was decided that this location was the preferable storage and shipping point for all three of these marsh deposits and that sulphur would be barged in liquid form from the outlying deposits. A new storage area at Port Sulphur is now under construction. A hydraulic fill to an elevation of about 8 ft has been placed on an area comprising 80 acres. A study of the soil encountered in shallow bore holes indicated that sulphur bins 30 ft in height could be supported on wood piling 30 to 70 ft in length if driven on 4-ft centers. With this load, ultimate subsidence is expected to be 2 to 4 ft. The driving of 25,000 pilings started in 1950 and is still in progress. These pilings will provide two parallel storage sites each measuring 200 by 1125 ft and when filled to 30-ft height will provide working storage of about 450,000 tons of sulphur. Cost of the hydraulic fill and pile driving is estimated at more than $1,000,000, which is a high penalty over land deposits where no such expenditure is necessary. Pile driving has been completed on a few of the bins, and some are now in use handling a portion of Grande Ecaille's production, which is barged in liquid form to this site.

The liquid sulphur barges as they arrive at Port Sulphur are emptied into tanks on the dock. From these the sulphur is pumped through surface lines to a number of small tanks, elevated about 45 ft, immediately adjacent to the sulphur bins. The elevated tanks hold about 20 tons of sulphur, are filled in 8 min and emptied in 1 min, and when pumped full automatically empty themselves through a siphon into the bin, where the sulphur distributes itself in a thin layer over the entire bin surface. The size of the tanks and the pumping rate are designed so that sufficient time is allowed for this layer of liquid to freeze and solidify before another layer is deposited. This method of freezing avoids the creation of pools or pockets of liquid sulphur within the bin and consequent hazard to operating personnel.

Forms to confine the liquid are composed of aluminum sheets which are periodically raised and reinstalled at a higher elevation as the bin progresses upward and removed when it has been filled to its full height of 30 ft. The bin is then ready for loading into ships, river barges or railroad cars. Loading equipment consists of power shovels, cross conveyors, and a main belt which conveys the sulphur to a tipple tower mounted on the river dock. Electric-driven shovels having 3½ yd dippers and equipped with magnetorque hoist, swing, and crowd mechanisms are used, see Fig. 7. This new type of shovel has proved very satisfactory in the dusty condition that exists when sulphur is being handled. Formerly sulphur bins were blasted before loading, but in recent years it was found that shallow bins can be shoveled without blasting, provided the shovels have sufficient power to withstand the added load. This shovel handles up to 500 tons per hr. The sulphur is received from the shovel by a movable cross conveyor, 185 ft in length with a 36-in. belt, which is equipped with a portable hopper and a specially designed screw feeder.[19] By choke-feeding the screw it serves as a crusher and reduces chunks over 3 ft in size to 10 in. and smaller before they reach the cross-conveyor. The cross-conveyor discharges onto the main belt, which carries the sulphur about 3300 ft to the tipple tower and thence into the holds of ships or river barges.

A sulphur dock 225 ft long with mooring piling which totals 936 ft in length has been provided in

Fig. 7—Three and one half yard electric shovels break down a vat at Freeport Sulphur's Port Sulphur storage site. A conveyor belt carries the sulphur to loading points.

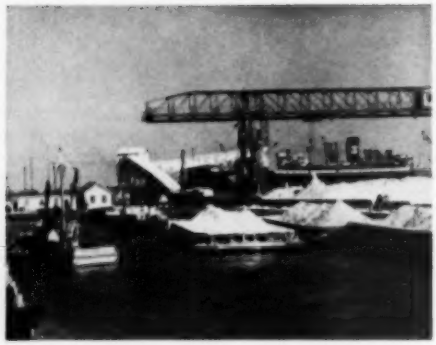

Fig. 8—The Mississippi dock of Freeport Sulphur at Port Sulphur, La., handles the entire output of the Grande Ecaille mine.

the Mississippi River at Port Sulphur, see Fig. 8. Original construction in 1933 required 95-ft piling, but recession in the river bank during the 1945 flood necessitated reconstruction with 12-in. pipe piling 135 ft in length. Recession of the river bank continues and revetment work will soon be necessary if sulphur shipments are to go forward. All types of ships are loaded, but maximum cargo lifted is about 11,000 tons. Maximum rate of loading ships will be about 800 tons per hr. River barges are loaded over the same dock and a transfer tower can divert sulphur from the belt conveyor to gondolas or box cars on a railroad siding located on the land side of the river levee.

Barging of hot liquids in tank cars or barges is not a novel feature, but the transportation of relatively large quantities of a crude, nonmetallic mineral in a liquid form is unusual. From Garden Island Bay to Port Sulphur the distance is 45 miles, and from Bay Ste Elaine 75 miles. The proposed barging routes are shown in Fig. 1. For the Garden Island Bay deposit four barges and three tow boats will be required and for the Bay Ste. Elaine deposit two barges and one tow boat. A liquid sulphur barge, illustrated in Fig. 9, will be 224 ft long, 39 ft across the beam, and 8 ft 5 in. in depth. When loaded with 1000 tons of liquid sulphur it will have a draft of 6½ ft. Although equipped with steam coils to prevent freezing of sulphur, no heat will be applied while en route because insulation will prevent excessive heat losses.

Since some of the barges must travel in the open water of the Gulf of Mexico they all have been designed to meet American Bureau of Shipping specifications for limited coastwise service which are considerably more rigid than those required for inland service. The twin-screw tow boats of all-steel construction will be 80 ft long and 22 ft in beam, will have a 6-ft draft, and will be equipped with two 400-hp Diesel engines. Communication equipment includes shortwave radio, ship to shore telephones, and radar. Cost of a 1000-ton liquid barge is estimated at $140,000 and the cost of each tow boat at $200,000. Total cost of transportation equipment for both Garden Island Bay and Bay Ste. Elaine will approximate $1,700,000.

Fog, wind, and storms will interrupt the scheduled transportation of sulphur from these mines. Some storage will be afforded by ample standby capacity in liquid barges, and this will circumvent the shutdowns of producing wells and the curtailment of production when transportation is interrupted.

Auxiliary Operations

Early in the development of Grande Ecaille, Freeport acquired a strip of marshland along the Mississippi River 10 miles east of the mine site and 45 miles below New Orleans. The surface of this area was elevated by hydraulic fill and the townsite of Port Sulphur was established. This townsite consists of 249 company-owned family dwelling units and dormitories for 194 single employees. Many employees have built homes on property adjoining the townsite. The permanence of Port Sulphur and the complete shop facilities at Grande Ecaille as well as their central location with respect to other new mines belonging to Freeport Sulphur Co. make these facilities ideally suited to central operating, maintenance, and administrative headquarters. At present all offices are located at Grande Ecaille. A new office will be erected soon at Port Sulphur where general supervision of all operations will center. Only operating departments will have offices at the various mines.

Transporting employees from Port Sulphur to Grande Ecaille requires a fleet of eleven 50-passenger, twin-screw Diesel-powered cabin cruisers, see Fig. 10. The remoteness of Bay Ste. Elaine and Garden Island Bay precludes daily crew changes, so that special schedules must be provided. Conditions

Fig. 9—A liquid sulphur barge. Capacity, 1000 long tons.

Fig. 10—One of the eleven 50-passenger boats which carry Freeport Sulphur employees between Grande Ecaille and Port Sulphur on the company-built canal.

at these mines permit no family dwellings or living with families at the mines, and dormitories with eating facilities must be provided.

Freeport's warehouse terminal at Harvey on the west bank of the Mississippi River across from New Orleans is the central receiving and dispatching station for materials and supplies en route to Grande Ecaille. Converted landing craft[10] used for tanks during the last war transport pipe and supplies to Grande Ecaille semiweekly, and barge trips are made as required for larger materials such as piling. This system is being expanded to include Garden Island Bay and Bay Ste. Elaine. The barge route is shown in Fig. 1.

A plant for centrifugally casting cement linings in steel pipe is operated at Harvey Terminal. Cement-lined pipe is used in all phases of operation involving handling of corrosive fluids. Costs range from $0.25 per ft for 4-in. pipe to $0.40 per ft for 8-in. pipe.

Two 12-in. hydraulic suction dredges are required for surface filling operations at Grande Ecaille. These dredges, one a Diesel-electric and the other an all-electric which uses plant power, each have dredging rates of 10,000 cu yd per day. They are capable of maintaining rates of 8,000 yd per day even though discharging two miles from the dredge cut.

Meteorological and Oceanographic Conditions

Grande Ecaille is located immediately to the west of the Mississippi River estuary and is protected by river levees from the damaging tides of most hurricanes. However, two unusual hurricanes have approached from a southwesterly direction, causing tides of 7 to 9 ft above sea level. These occurred in 1893 and 1915. No serious tidal conditions have been experienced since the plant was put into operation in 1933. The plant is alerted for hurricane precaution on an average of about twice each year, but to date complete evacuation has not been necessary.

Some serious fog conditions have been experienced in canal traffic between Grande Ecaille and Port Sulphur. Line squalls developing winds up to 70 miles per hr have also disrupted canal traffic on several occasions. Normal tides range from minus 2 ft during severe northers to plus 3 ft during southwesterly squalls. Annual mean temperature is about 70°F and annual mean rainfall about 65 in.

A meteorological and oceanographic report[14] prepared on the Garden Island Bay area points out that this exposed location on the southeastern tip of the Mississippi River estuary is more vulnerable to storm conditions than Grande Ecaille. According to this report, hurricane winds can reach a velocity of 135 miles per hr which can cause tides of 12 ft above mean Gulf level and up to a maximum of 17 ft where movement of the tides is obstructed. Hurricanes with winds of lesser velocity, but in excess of 50 miles per hr, can be expected once each 1.78 years. In addition, heavy fog will occur frequently during winter months and wind swells in the Mississippi River will prevent barging on an average of 2 days per month.

The Bay Ste. Elaine area lies some 75 miles west of the Mississippi River estuary and will not receive the protection from hurricane tides that exists at Grande Ecaille. Situated on the west side of a large bay, it is exposed to the maximum storm tides within the bay. Wind, tide, and wave conditions are expected to be approximately the same as those indicated for Garden Island Bay. Transportation from Bay Ste. Elaine to Port Sulphur is routed through the Gulf of Mexico for a distance of 45 miles, and it is anticipated that wave conditions[15] over this section of the Gulf will make barging hazardous during 20 pct of the time, but because of the distance of the Bay Ste. Elaine area from the Mississippi River, fog will probably be negligible.

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The Development of A Mining Operation From Diamond Drill Data

Fig. 1—The surface plant, Howe Sound Exploration Co., Ltd., Snow Lake, Manitoba.

by George C. Lipsey

FOR many years the mining of coal and other minerals occurring in sedimentary formation has been planned according to information obtained by diamond drilling. Placer mines have used churn drills for sampling and estimating deposits, and some metal mines have used the method either wholly or in part. The diamond drill method, therefore, although not entirely new, has come into more prominence in the last few years. Several large-scale developments now being planned or in the production stage have used this method in varying degree. This paper will describe the operations of the Howe Sound Exploration Co., Ltd. at Snow Lake, Manitoba, where a gold mine was developed and equipped for mining and milling wholly on the basis of diamond drilling results. The property has been in operation nearly 3 years, so that results can be compared with the estimates and assumptions made from the diamond drilling.

In developing the subject it is necessary to outline as briefly as possible the normal method of mining, from discovery to production stage. Table I sets forth these various stages, the methods of financing, the percentage of total cost, and the relative time interval required for each section of the work. The plan presented in this table cannot be applied to all mining developments, but it gives a basis on which to work. In Stages 2 and 3 the investment is moderate, and if the property does not respond favorably the options or interests can be terminated. Stage 4 represents a sizeable investment, and it is more difficult to drop the property after this part of the operation is completed. Stages 2, 3, and 4 may be repeated several times by different groups or companies before Stage 5 is reached, but when Stage 5 has been started the total capital investment must be provided and there can be no turning back.

It will be noted that there is a total of 116 units of investment in the overall cost if one company proceeds with Stages 2, 3, 4, and 5 in order. Stage 4, however, consumes time which is important when markets are being considered. Bringing a property into production when metal prices are low is much more difficult than when the prices are high, and if this stage can be set aside production is attained more quickly. When Stage 4 is eliminated the total becomes 86 units of cost for Stages 2, 3, and 5, but an adjustment of 14 units must be added to Stage 5. These 14 units represent the useable value of Stage 4. Thus Stage 4 represents an investment of 30 units if carried on before Stage 5, but 14 units if included with Stage 5. This is accounted for by the fact that development work can be accomplished more cheaply under Stage 5, since everything that is done is planned on a production basis with permanent services. Stage 4 must of necessity be governed by expenditures, and a great many temporary services, including housing and power plants, must be provided. The prospect shaft is a small one, and drifts,

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Discussion on this paper, TP 3354A, may be sent (2 copies) to AIME before Sept. 30, 1952. Manuscript, Dec. 14, 1951. New York Meeting, February 1952.

crosscuts, and raises are driven as small as possible for the purpose of obtaining the information required at the lowest possible cost. On the assumption, therefore, that Stage 4 can be eliminated, a saving of approximately 16 units can be effected.

The capital required to complete Stages 2 to 6 varies from 107 to 123 units of cost, not taking into consideration the cost of the property. It will be observed that in Stage 6 there is an allowance of 7 units of cost which may be higher in certain operations.

Location, Topography, Vegetation, and Climate of the Snow Lake District

Snow Lake is situated in northern Manitoba at Latitude 54°55′ and Longitude 100°. It is 400 miles northwest of Winnipeg, 80 miles northeast of The Pas, 80 miles east of Flin Flon, and 38 miles from Wekusko, a siding on the Hudson's Bay Railroad which runs from The Pas to the Port of Churchill on Hudson's Bay. It is close to the southern edge of the Precambrian Shield. The topography is typical Precambrian country of low relief with many muskegs, lakes, and rock ridges with clay overburden in the depressions. The vegetation consists of spruce, poplar, birch, jackpine, and tamarack trees with occasional fair stands of merchantable spruce. Heavy moss covers most of the ground except for a few small grassy plots on edges of lakes and rivers. There is a wide variation in temperature between summer and winter.[1] In summer the days are long with 21 hr daylight in June, and temperatures vary from 70° to 95°F. In midwinter there are 8 hr of daylight and temperatures throughout the season vary from −15° to −50°F and occasionally lower. Although the days are short in winter they are generally bright and sunny. The lakes are frozen over from November to May. By mid-April the winter snows on the land are generally gone. Average yearly precipitation amounts to 11½ in. of rain, most of which falls in heavy thunderstorms in June and July, and 40 in. of snow, which rarely lies over 2 ft deep on the ground. Until an all-weather road was constructed to Wekusko all heavy supplies were hauled by tractor and sleigh over the frozen lakes and muskegs from late December to the end of March. From May to October pontoon-equipped planes or canoes and portages provided transportation.

Fig. 2—The Howe Sound Exploration Co. plant at Snow Lake in relation to the townsite.

Stage 1, Discovery: The exact date of the gold discovery at Snow Lake is not known, but it is thought that work was done on the property before the turn of the century. Chris Parres Associates restaked the claims in 1927 and did considerable trenching between this date and 1938, when Nor-Acme Gold Mines Ltd. was incorporated.

Stage 2, Preliminary Examinations: Frank Ebbutt, geologist for the Howe Sound Co., examined the property in the fall of 1940 and sampled the surface outcrops. He returned in the spring of 1941 and drilled 5 shallow holes with an X-ray machine. The results of this drilling were encouraging, as the values averaged better than those of the surface outcrops. An option to lease the property from the Nor-Acme Co. was then entered into.

Table I. Stages of Mining Development from Discovery to Production

Stage No.	Stage of Development	Financing	Units of Cost	Time Interval
1	Discovery	Prospector Grubstake Government assistance Mining company	A few hundred dollars to 1 unit	1 to 20 years
2	Preliminary Examinations	Individual Partnership Syndicate Mining company	A few thousand dollars to 1 unit	A few weeks to several months
3	Preliminary Development Includes surface trenching, diamond drilling, geological mapping, geophysical or geochemical prospecting, and in some cases underground work	Partnership Syndicate Sale of stock in company formed to develop the prospect Funds provided by mining company	Several thousand dollars to 2 units	6 months to 3 years
4	Underground Development To block out positive ore reserves	Sale of company capital stock Funds provided by mining company	30 units	2 to 5 years
5	Installation of a Mining and Treatment Plant Includes the development of the mine for mining, the mining plant, the treatment plant, power and water supply, transportation facilities, and townsite.	Further sale of company capital stock Funds supplied by mining company Bank loans obtained by an established company Sale of bonds	83 units	2 to 3 years
6*	Tune-up period merging into production stage	Working capital which must be provided from the above sources or generally by a bank loan until returns from the operations are made available	7 units	1 to 6 months

* Cost of property must be provided for and may vary from 1 to 30 units.

Stage 3, Preliminary Development: Diamond drilling was started on August 29, 1941, and continued throughout the winter of 1941-1942. From 103 holes, totaling 50,000 ft, there was an EX core recovery of 100 pct. The deep holes were surveyed. The whole core was used for a sample and 8-ft sections were standard. Rejects of all samples were saved for metallurgical test work and check assays. The diamond drilling outlined two orebodies containing roughly 5,000,000 tons of low grade arsenical gold ore. The Dick orebody was drilled to a depth of 1000 ft, roughly 700 ft in length, with an average width of 70 ft. The Toots orebody was drilled to a depth of 400 ft and showed a length of 400 ft and an average width of 16 ft. The 52 claims in the group were surveyed for lease and a geological map of the claims was made in the spring and summer of 1942. Active work at the property ceased during World War II.

Investigations Made Between 1942 and 1945

The rejects from the drill core samples were made up into composite samples for test work and testing was carried on independently at two of the company's operating divisions at Holden, Washington, and Britannia Beach, B. C. A satisfactory flowsheet for the treatment of the ore was worked out.

Estimating of Ore Reserves from Diamond Drill Results: Independent estimates of the orebodies were made by two groups of company engineers both as to grade and tonnage. These estimates were remarkably close. The following points were considered in arriving at the grade of the ore: 1—Core recovery in the ore sections was 100 pct. 2—Original assays were checked independently by another assayer. The assays of the rejects, used for making composite samples for testing, were checked by three independent custom and two Howe Sound assayers. The calculated heads from test work were checked against the assays heads. 3—There were no extremely high assays or extremely low ones within the ore zones. 4—Calculating by the ounce-foot method, the ounce-block method, and an arithmetical average of all ore samples checked closely. 5—The method used to correct for erratics, developed by the Hollinger Gold Mines,[1] was used to make a calculation of the ore grade and to check the other methods employed. 6—The variation in all the estimates of grade was less than 4 pct. 7—The total weight of samples from the drill core in the ore zone was approximately 1.6 tons, the ore sample being 1 part in 3,000,000. If the core had split, as it commonly does, the ore sample would have been 1 part in 6,000,000. It is believed that results would have been the same.

Consideration of Mining Methods from Diamond Drill Records: A study of geological data, diamond drill core, and drill logs brought forth several facts which were of help in developing a mining method. It was found that the wall rock as well as the ore was very competent and that a mine relatively free from costly timbering could therefore be anticipated. The impervious clay overburden was tight to the bed rock, very little porous sand was encountered, there were no large fault zones, and no water appeared in the various formations. It was evident that the ore zone would lend itself to breaking with diamond drill holes or long hole drilling.

A mine model made up from the drill logs revealed further advantages. It was shown that the walls were fairly regular, with no apparent bad rolls, and that the dip of the footwall varied from 45° to 60° with an average of 53°. The length of the Dick ore zone was approximately 700 ft, the width varying from 30 to 100 ft with a 70-ft average. The length of the Toots zone was about 400 ft and the width varied from 10 to 30 ft with a 16-ft average. It was observed that the orebodies had a rake or plunge of 45° to the east. This indicated that the ore could be mined from the top down, level by level, the sill pillars being recovered as the mining progressed and the subsidence of the hanging wall, if any, being delayed until the stopes on the lower levels were mostly under solid ground. Provision for filling could be delayed with reasonable safety for several years. It was apparent that the orebody would lend itself to cheap primary breaking by some method of long hole drilling and that it was large enough to produce 2000 tons a day from one level, indicating a concentrated mining operation. The ore could be drawn through bulldoze chambers or by scrapers.

In 1944 the writer saw the district for the first time, spending the better part of two weeks studying operating conditions in this northern section of Canada on property owned by the Hudson's Bay Mining & Smelting Co. and the Sherritt Gordon Mines Ltd. Much valuable information was gathered at this time.

To plan intelligently during the next winter it was necessary to obtain definite information on access to the property and also to check the location for shaft and mill sites. A small survey party was assembled in July, and between August 1 and October 31 the following work was completed.

Preliminary road survey was made from Snow Lake to Wekusko on the Hudson's Bay railroad a distance of approximately 38 miles; a contour map of the surface area was made on 5-ft intervals with 2-ft intervals on likely areas for the shaft and milling plant. From the preliminary geological map several possible mill and plant sites were selected and these spots were mapped in detail. Where clay overburden covered the bedrock, soundings were made with auger drills to a depth of 10 ft so that the bedrock detail was known as well as the surface detail. When the contours were plotted, sections on the co-ordinate lines were made of the bedrock and surface, with the overburden colored. From this plan estimates could be made of general excavations and foundations. Model buildings could be placed on the plan and the foundation excavation and bedrock for footings could be visualized at a glance by using the contour plan with sections on the co-ordinate lines on the same map.

After the above information was obtained, possible sites for the shaft and plant were soon narrowed to three locations. Each was assessed as to: 1—The relation to known orebodies and possible extensions. 2—Freedom from the effects of subsidence at a later date. 3—Possibilities of placing the mill building so that any natural slope could be used for gravity flow in the milling operation. 4—The best foundation footings for the buildings and machinery. 5—The minimum surface excavation. 6—Possible townsite locations. 7—Water supply.

The location which best suited all requirements was located a few hundred feet east of the surface showings on a relatively high large outcrop. There was a good mill site and yard area and sufficient room for proposed plant buildings and expansion. The only disadvantage was that the general rock excavation was heavy.

Completion of Stage 3: By the end of 1944 Stage 3 was completed and the following facts determined about the property. By diamond drilling a possible 5,000,000 tons of low grade arsenical gold ore above the 1000-ft level had been blocked out. The chances of finding more ore were good. Mineralogically there was no change in the ore for 1000 ft so no sudden changes in depth were to be anticipated. There was no rapid dropoff in grade of ore in the first 1000 ft as the values were remarkably uniform throughout. Although only a few holes penetrated to a depth of 1000 ft there was no indication as to rapid diminishing of the size of the Dick orebody. The orebodies were centrally located in the group of claims allowing considerable scope for further prospecting. It is a miner's faith that orebodies of this type are not orphans and that the development of one orebody generally leads to the finding of others. According to the old adage, "Ore Begets Ore."

According to the rejects from diamond drill core samples two flowsheets had been worked out for treating the ore: 1—flotation, followed by cyanidation of the concentrates, with recoveries estimated at 80 to 83 pct, and 2—flotation, followed by roasting of the concentrates and cyanidation of the calcines, with recoveries estimated at 85 to 90 pct.

The main extraction shaft and mill site had been tentatively located, a proposed mining method had been developed for mining of the ore, and the following items had been investigated: labor and material supply, power, transportation, water supply, townsite, and source of sand and gravel. An estimate of the cost of a complete mining and milling plant of 2000 tons daily capacity had been made, as well as an estimate of the probable cost of operating and the possible financial outcome of the operations.

Up to this time the Howe Sound Exploration Co. investment in the property was nominal. To proceed with Stage 4 would represent a considerable capital outlay. Because of such factors as the isolation of the property and the lack of power and of transportation facilities, a large capital outlay would be required to carry out an adequate underground development program to block out positive ore reserves. The idea was then advanced as to whether Stage 4 could be eliminated and a decision made to go directly to Stage 5 and bring the property into production without waiting for underground investigation.

This idea was a radical departure from accepted mining practice. The advantages of eliminating Stage 4 were that a considerable saving in total capital outlay could be made, and the production stage reached at least 2 years sooner. The disadvantages were that the total capital outlay had to be provided and that there was no turning back once started. If Stage 4 was proceeded with, at least 30 pct of the total estimated capital investment would be spent to bring the property to the production stage. There was a question as to whether the company, after spending this amount of money, would be in any better position to judge the expected grade of the ore, as the same factors which make appraisal of values in drill cores difficult would still continue and possibly the actual true grade would not be determined until "experience factors" based on milling results could be developed. Ground conditions, of course, would be better known.

The careful examination of all factors mentioned previously made it possible for the engineers to recommend to the management that a definite decision be made to bring the property into production without waiting for underground investigation or Stage 4 in the ordinary process of development.

It should be stressed that in making this recommendation the engineers needed considerable courage, but their decision was simple compared to the problem faced by the directors, who had to decide on a very large capital outlay based on the results of diamond drilling with no checking of this information by underground investigation.

In early 1945 it was decided to bring the property into production as soon as possible and to omit Stage 4. As the cost of a roasting plant to treat 100 tons of arsenical concentrates would be high and the storage of arsenious oxide derived from the roasting would be difficult, it was decided to use the straight cyaniding of concentrates flowsheet and store the cyanide residues for future treatment. With the cessation of European hostilities and the impending collapse in the Japanese theater of war a start was made on the development in August, 1945.

Stage 5: The purpose of this paper is not to describe in detail the plant construction or mine development, which will be the subject for a later article. Fig. 1 shows the surface plant and Fig. 2 the plant in relation to the townsite.

Stage 6, Production Stage: The milling plant was started late in March of 1949 and the first bullion poured on April 22. In April and May there was considerable difficulty, which was not overcome until June, with ore hanging up in the raises. June tonnage was 1600 tons per day, increasing to 1800 tons in October and 1900 tons in November. It has continued at a nominal rate of 2000 tons per day since. There were the usual problems of tuning up and starting a mining operation. To date the 320 level has been mined out in the Dick orebody except for the surface pillar. The 580-level stope in the Dick orebody is approaching the 320 sill, and the 780 level is being prepared for mining. A small shrinkage stope is being mined in the Toots orebody above the 320 level. The sinking of the shaft was completed to 1470 ft in September 1951, bringing in two more levels for mining and a third, the 1280 level, for development.

Results After Mining 1,550,000 Tons of Ore

The Checking of the Assumptions as to Mining Methods from Study of Drill Cores and Logs in the Preliminary Stage: 1—Ore and wall rock is very competent. No timber sets have been required to date. Shaft lagging is not required except at stations, since there is no sloughing in empty stopes. 2—The attitude of the walls is not quite so regular as anticipated. 3—The underground water, approximately 50 gal a min, has to be pumped. 4—In primary breaking, flat hole-ring drilling from footwall raises started with diamond drilling AX holes, superseded by tungsten carbide bits, 2 in. and 2⅛ in. in size, with sectional rods, burden 10-ft vertical, spread on a hanging wall approximately 20 ft. The powder factor to date is .272 pounds per ton, including undercuts. 5—On the 320 level the ore was drawn through bulldoze chambers spaced at 35 ft with a grizzly spacing of 30 in. On the 580 level the ore was scraped directly into 100 cu ft Granby-type cars with 60 hp slushers, ¾-in. cables, and 54-in., 60-in. and 66-in. scrapers, both folding and rigid types. The maximum pull was 120 ft. All production is obtained from one level, with slight overlap when a new level is being brought into production. 6—No

unnecessary drifting, cross-cutting or raising was done. To date there are probably only 100 ft of drifting not being actually used in the mining operations.

Recoveries have been very close to the estimated and are currently running at 80 pct.

Preliminary Ore Reserve Estimates as Compared to Millheads

After the milling of 1,550,000 tons the grade of ore milled has been 8 pct lower than the original ore estimates, with no allowance for dilution on the original estimates. If a normal 10 pct dilution factor had been used the tons milled to date would have roughly averaged 2 pct higher than the estimated grade. It is estimated that when 2,000,000 tons are drawn the millhead grade will be within 5 pct of the original estimate.

General Facts of Operations in the Mining of the First 1,550,900 Tons

Twelve tons are produced per underground man-shift, 6 tons per overall man-shift, including all employees, 55 milled tons per manshift, and 55 to 60 tons per manshift in bulldoze chambers or scrapers. There are 60 tons produced per ft of development driven, and 30 tons per ft of exploration diamond drilling. The average length of development rounds is 7 ft. Tungsten carbide drilling for blast holes amounts to 66 pct of the cost of diamond drilling. The ratio of labor to supplies is about equal.

When a correction is made for increased labor costs of 50 pct and supplies of at least the same percentage, the current costs are below the estimated costs. Capital costs were higher than anticipated because of the large increase in cost of labor and supplies during construction between 1946 and 1949.

To summarize, it is believed that with certain types of orebodies it is possible to calculate ore plants, even at a newly discovered property remote from other mines, wholly on the basis of information obtained from diamond drilling.

Reference

[1] Canadian Institute of Mining and Metallurgy *Bull.* (1943) pp. 209-225.

High-Efficiency Desliming By Use of Hydraulic Water Additions To the Liquid-Solid Cyclone

by D. A. Dahlstrom

THE necessity for slime elimination from valuable mineral and coal products has become increasingly significant within the past 5 years.[1, 2] Most of the mechanized mining and present beneficiation methods have resulted in larger tonnages of extreme fines, silts, and clay, commonly called slimes, processed by the preparation plant. Economics in turn have forced the plant operator constantly to lower the bottom size of effective beneficiation, necessitating an almost complete recovery of valuable solids regardless of particle size. When these important factors are considered, the need for an efficient slime removal method for fine solids becomes self-evident.

Ordinarily slimes have been classified as ranging from 75 microns, or 200 mesh, down to colloidal dimensions of less than one micron. At the same time there is general agreement that the most troublesome slimes are primarily clays, silts and extreme fines, so that the actual top size may be placed at approximately 30 to 40 microns. This immediately restricts any desliming operation to classification, as screening or other methods would be both uneconomical and grossly inefficient at such dimensions.

The liquid-solid cyclone has been recognized as one of the most efficient fine size classifiers available to the mining industry. Applications of cyclones to thickening, high efficiency solid recovery, degritting,

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Discussion on this paper, TP 3353F, may be sent (2 copies) to AIME before Sept. 30, 1952. Manuscript, March 10, 1952. New York Meeting, February 1952.

Table I. Typical Desliming Results with Cyclones

Solids, Type	Cyclone Diam 24-In.	24-In.	9-In.	14-In.	9-In.
	Phosphate Rock[10]	Phosphate Rock[10]	Coal	Coal	Sand
Feed					
Pressure—psi	14	14.0	3½	25	10
Solids, pct	20.4	20.2	15.71	11.72	41.6
—200 mesh, pct	40.8	22.9	43.7	28.5	3.0
Tons per hr solids	49	41.4	3.32	6.14	28.7
Gpm slurry	780	776	79.3	203.4	221
Tons per hr per ft² (solids)	15.6	13.17	7.51	5.75	65.0
Gpm per ft²	250	247	180	191	500
Overflow					
Solids, pct	10.1	5.1	8.60	2.98	1.98
—200 mesh, pct	90.7	91.9	81.4	73.5	96.94
Tons per hr solids	22.0	9.6	1.32	1.75	0.7
Gpm slurry	692	694	67.8	174.8	143
Underflow					
Solids, pct	71.4	76.8	32.6	33.4	78.0
—200 mesh, pct	5.6	2.0	11.8	5.2	0.6
Tons per hr solids	27.3	31.8	1.90	4.39	28.0
Gpm slurry	93	88	11.5	28.6	78.0
Recovery of 100x200 mesh solids in underflow, pct	87.0	72.5	41.1	62.5	100.0
Elimination of —200 mesh, pct in overflow	93.2	93.2	85.4	87.1	80.0
Feed water to cyclone underflow, pct	4.3	6.0	9.1	8.3	19.9
Desliming coefficient	1.58	1.13	1.60	1.55	1.004

and heavy media beneficiation are well known and widely reported in the literature.[2-5] Simultaneously the cyclone has been put to practical use for high-speed slime removal, particularly in the coal, phosphate, and sand industries.[6-9] In all such instances, desliming efficiency must be measured not only by the percent of slime removal but also by the recovery of valuable solids, especially the 100x200 mesh material, in the cyclone underflow. A third index of efficiency if the cyclone is operating with a properly thickened underflow is the desliming coefficient.[7,8] This has been defined as the percent of feed slimes recovered in the cyclone underflow divided by the percent of feed water reporting to that point. Desliming coefficients for any nonhydraulic water classifier can *at best* exhibit a *minimum* desliming coefficient of 1.0. Evaluation of desliming equipment should properly take into consideration these three factors as well as economic and operational qualities.

Table I illustrates typical cyclone desliming operating results on various solids. Capacities range from 180 to 500 gpm per sq ft of cyclone cross section for feed slurries and 5.75 to 65.0 tons per hr of feed solids per sq ft of cross section—the highest capacity of any fine size classifier. Attention should also be focused on the high recovery of 100x200 mesh solids in the cyclone underflow, the 80 to 93.2 pct removal of slimes, and the low desliming coefficients. The cyclone when correctly applied will consistently exhibit desliming coefficients approaching more closely the theoretical minimum of 1.0 for nonhydraulic water units than other types of classifiers.

In cases where feed solid loading is high or pressure available is low, it may be more expedient to utilize a two-stage process.[6,9] In this instance the overflow from the primary cyclones is fed directly or through a pump to secondary units where the remaining desirable solids are deslimed. Typical results from two installations are given in Table II. Data for each stage are comparable with those in Table I, while overall recovery of desirable solids is very high.

In many desliming processes on fine solids, slime removals of 80 to 90 pct are unsatisfactory. Two predominant reasons can be cited for the higher restrictions. 1—In today's market, there is an ever-increasing demand for higher purity in fine solids, necessitating slime removals of higher than 95 pct. 2—Because of water shortages, waste water disposal restrictions, or high clay percentages in the run-of-mine solids, circulating water slime contents must be held at a relatively high level in many preparation plants. Thus it is not uncommon for the slurry fed to a desliming operation to have a slime content in the total solids of greater than 30 or 40 pct.

There are two possible solutions to the above problems if they are to be solved by classification. The first, reported in an earlier paper,[8] consists of repulping the thickened underflow with fresh water

Table II. Typical Two-Stage Desliming Cyclone Results

	Coal[7]			Sand		
	First Stage, 2 to 20-In. Cyclones	Second Stage, 6 to 14-In. Cyclones		First Stage, 2 to 36-In. Cyclones	Second Stage, 2 to 20-In. Cyclones	
Cyclone pressure drop—psi	8	26		3½	4½	
Feed—per cyclone					10.83	
Solids, pct	13.12	10.3		45.0	20.8	
—200 mesh slimes, pct	29.0	41.5		3.0	10.2	
Tons per hr solids	33.75	7.22		151.2	621.0	
Gpm slurry	900.0	272.0		962.0	3.7	
Tons per hr per ft² (solids)	15.4	6.76		21.4	126.3	
Gpm per ft²	410.0	254.0		136.0		
Overflow per cyclone					2.54	
Solids, pct	10.3	5.83		10.83	96.3	
—200 mesh slimes, pct	41.5	77.9		20.8	3.8	
Tons per hr solids	21.65	3.72		18.2	587.0	
Gpm	815.0	250.0		621.0		
Underflow per cyclone						
Solids, pct					78.0	
—200 mesh slimes, pct	48.6	54.8		79.3	8.9	
Tons per hr solids	6.8	10.6		6.6	14.4	
Gpm slurry	12.1	3.5		133.0	34	
	85	22		140.0		
Elimination of —200 mesh slimes to overflow, pct	92.25	88.7		82.6	98.5	
Desliming coefficient	1.23	2.46		1.0	1.205	
Overall —200 mesh recovery		89.5			99.9	
Overall pct —200 mesh slimes in product		8.4			0.62	

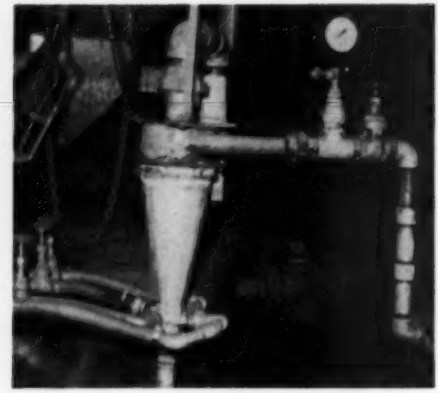

Fig. 1—Experimental hydraulic water cyclone.

and reclassifying so that total slime removal will be at the proper level. This course is entirely feasible, but another stage of classifying units plus the auxiliary equipment of pumps, surge tank, and pipe lines is a drawback. Furthermore, water requirements may be higher than those necessitated by the second solution.

The second solution involves lowering the desliming coefficient of the classifier by addition of hydraulic water so as to force more of the slimes to the overflow.[5] The cyclone appears particularly applicable to this modification. Its classification efficiency is already high, indicating that the amount of hydraulic water will be relatively small. This will be especially true if the water can be introduced at a point where solid concentration is relatively high and thus associated with the least amount of slime-bearing water. Furthermore, definite economy and process simplification would be effected by performing the high slime removal in one unit.

Hydraulic Water Cyclone Theory

Criner in a recent paper made an extensive theoretical analysis of the liquid solid cyclone, discussing in detail the flow pattern within the unit.[6] From experimental evidence and a mathematical study he proposed that radial flow into the cyclone core between overflow and underflow ports is uniform at any radius within the cyclone. Thus radial velocity at a radius r_1 lying between the overflow and underflow nozzles is independent of elevation. Furthermore, he hypothesized that after a fluid particle reached a certain plane near the apex of the cyclone, it could then no longer return in a path towards the overflow but must be discharged in the underflow. The location of this plane is directly proportional to the percent of feed volume reporting to the underflow. Thus if the fluid particle attains a level normal to the cyclone cross-section, whose ratio of distance from the underflow divided by distance between overflow and underflow nozzles is equal to the volume fraction reporting to the underflow, then that fluid must exit from the underflow. As a simple example, suppose that there is a 20 in. distance between overflow and underflow nozzles. If the cyclone operates with a 20 pct volume split to the underflow, when any fluid travels to within $0.2 \times 20 = 4$ in. of the underflow, it must eventually be discharged from that port.

In view of the above facts, it would appear appropriate to inject the hydraulic water at or slightly above the level at which all water reports to the cyclone underflow. Thus it may be possible to replace the slime-bearing water with fresh water, forcing the former to report in larger percentages to the overflow. This replacement would be considerably more efficient than dilution of the slime-bearing waters; accordingly lower slime contents in the cyclone underflow could be expected. If the water is introduced at a level closer to the overflow, larger amounts would be required to do the same job, while introduction at levels nearer the apex might seriously disrupt the cyclone flow pattern at high hydraulic water rates. The latter would be caused by forced movement of undesirable fluid towards the cyclone overflow, resulting in an inefficient centrifugal force field.

In order to maintain the flow pattern within the cyclone, the hydraulic water should be added tangentially in the same direction as the feed nozzle. By this means, further energy will be added to maintain the same centrifugal force pattern and prevent loss of solids above the normal classification point to the overflow.

Experimental Equipment

To test the proposal, a 9-in. cyclone of galvanized sheet metal was constructed with a 2-in. standard pipe feed entry and a 2½-in. I.D. copper tubing overflow. The included angle was 20°, and interchangeable underflow cones were made of different lengths so that any underflow diameter could be obtained. Four standard 1-in. pipes were brazed to the unit at 90° around a circle normal to the cyclone centerline near the apex. Through flexible connections from regulating valves on a 2-in. manifold to the tangential nozzles, hydraulic water could be admitted to the cyclone. Water rate was measured by a calibrated orifice on the 2-in. line. The unit was then installed at the preparation plant of the Truax-Traer Coal Co., Fiatt, Ill., to obtain experimental evidence. Fig. 1 shows the cyclone placed on the circulating water line of the washing tipple.

In performing tests, rate and analyses samples were taken of both overflow and underflow streams as well as feed pressure and hydraulic water rates. From this data it was possible to back-calculate to the feed conditions.

At the Fiatt Plant the −200 mesh fraction could not be considered as containing only slimes. There are small quantities of pyrite, calcite, sand, and high-ash coal which are of near 200 mesh size. Thus to eliminate these by classification would entail severe losses of coal up to 30 or 40 mesh in size. Naturally this cannot be tolerated, and such particles must be removed by other cleaning methods. It should be pointed out that in most cases the quantity of these near mesh solids is relatively small in comparison to the amount of true slimes present. However, because of their size and density, the former will report primarily to the underflow while the true slimes will report chiefly to the overflow. Thus if a distinction is not made between the two classes of solids, a true picture of desliming results will not be obtained in any test work. Furthermore, the near mesh material is not responsible for the lowered capacity and excessive moistures in the mechanical dewatering and thermal drying process steps, and because of its usually low concentration does not contribute as significantly to higher impurity percentages as do the greater quantities of slime.

The Fiatt slimes had a top size of approximately 25 to 30 microns. Accordingly in this study all wet screen analyses were performed with a bottom screen of 200 mesh. The −200 mesh solids were thoroughly agitated and allowed to settle 1 min to permit the +30 micron material to separate. The slime-bearing water was then carefully decanted and the near mesh solids transferred to a beaker. The latter were thoroughly rinsed three times with fresh water and decanted as before. When all slime-bearing waters were combined and filtered, a sufficiently accurate analysis for −30 mitron slimes was possible. Several runs were made to test and prove the reproducibility of the results.

Test Results

The unit was first installed on the circulating water line of the plant where cyclone feed pressures up to 15 psi could be obtained by use of a throttling valve. Several preliminary runs were first made to determine the feasibility of the hydraulic water design. Results indicated desliming coefficients could be lowered to less than 0.35 with only about 25 pct of the total feed water, that is, slurry water plus hydraulic water, being fresh water additions. Such operation would permit elimination of 93 pct or better of all slimes fed to a cyclone.

This result apparently substantiated the original hypothesis that the hydraulic water additions were largely replacing rather than diluting the slime-bearing water. To add weight to this conclusion a series of tests were made at constant cyclone nozzle dimensions and a feed pressure of 5 psi with varying amounts of hydraulic water rates. Desliming coefficients were calculated and plotted as a function of pct hydraulic water volume of total feed volume as indicated in Fig. 2. A reasonable smoothed curve of the data exhibited a straight line relationship for hydraulic water percents of total feed volume above 7.5 pct.

To establish the significance of the above results, some important background material must first be discussed. The distance between overflow and underflow nozzles in this series of tests was 24¼ in. with the top of the hydraulic water nozzles located on a plane 7⅜ in. above the underflow. According to the cyclone radial flow theory previously mentioned, $(7\frac{1}{8} \div 24\frac{1}{4})100 = 30.4$ pct of the *total* feed volume, which is slurry plus hydraulic water, will pass this plane. Theoretically then, the maximum amount of hydraulic water that could be fed to the cyclone at this point of insertion is 30.4 pct of the *total* feed volume minus the volume occupied by the underflow solids. Lesser percentages could be added without any injury to the flow pattern, but greater quantities might force appreciable amounts of coarser solids to the overflow because of excessive radial velocity currents.

While solid concentration in the plant circulating water ranged from 11 to 12 pct by weight, −200 mesh content of the solids averaged 80 pct by weight with only 10-15 pct coarser than 100 mesh. Accordingly volume splits to the underflow ran less than 3 pct of the total feed volume. Approximately 50 pct of the underflow volume was occupied by solids, indicating a theoretical maximum amount of hydraulic water for these tests of $30.4 - 0.5x3 = 28.9$ pct of the *total* feed volume. Because of a lack of water pressure, hydraulic water percent of *total* feed volume never exceeded 28.5 pct and the theoretical maximum could not be checked. Even at the highest rate, however, no loss to the overflow of solids above the classification point for nonhydraulic water conditions was experienced.

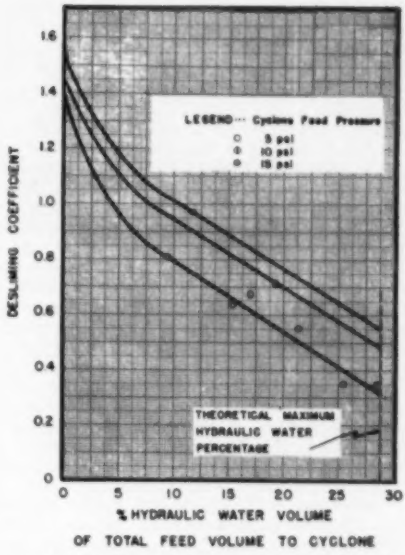

Fig. 2—Desliming coefficient as a function of hydraulic water volume percentage of total cyclone feed volume.

Referring again to Fig. 2, the theoretical average minimum desliming coefficient at the maximum hydraulic water rate would be 0.31. If the hydraulic water additions were entirely a replacement rather than dilution of slime-bearing waters, the desliming coefficient should equal the perfect value of 0.0. However, it will be observed that the desliming coefficient averaged 1.35 for the case in which no hydraulic water was added, indicating that the centrifugal force field utilized in this cyclone was above that required to have no concentrating action on the slimes. In other words, if this latter desliming coefficient had been equal to 1.0, then a perfect value of 0.0 for this same term should be expected at the maximum hydraulic water rate. Naturally, there will be some mixing of slime-bearing and fresh water, but with the above consideration the assumption of a largely displacement action of the hydraulic water seems justified. The original desliming coefficient for no hydraulic water additions was $1.35 - 1.0 = 0.35$ points above its theoretical minimum of 1.0, while at maximum hydraulic water additions the desliming coefficient was 0.31 points above its theoretical minimum of 0.0.

Further proof of the influence of centrifugal force on the vertical displacement of the correlation of Fig. 2 was obtained by performing more runs at feed pressures of 10 and 15 psi. At the resultant higher centrifugal force fields the curves were displaced upwards to higher desliming coefficients at the same hydraulic water percentage rates as indicated in the graph. This not only strengthens the displacement theory, but also emphasizes the importance of correct cyclone design and operation to obtain a centrifugal force field that will yield maximum slime elimination. This must be tempered by considerations of desirable fine solids recovery in

the cyclone underflow. If maximum slime elimination were the sole criterion, the feed pressure that should be used for any hydraulic water cyclone would be the maximum value that would still yield a desliming coefficient of 1.0 if no hydraulic water is admitted.

The hydraulic water cyclone was next installed on the underflow line from the fine coal settling cone to obtain additional data. Unfortunately the solid concentration in this feed slurry ranged from 22.5 to 28.18 pct by weight, necessitating volume splits in excess of 31 pct to the underflow with no hydraulic water additions to the cyclone. As larger underflow nozzles had to be used to accommodate the greater volume rate at this port, the hydraulic water jets were only 15.6 or 20.6 pct, depending on which of the two possible insert cones were used, of the overflow-underflow distance away from the underflow. According to cyclone flow path theory, hydraulic water introduced closer to the apex than the plane at which all volume will report to the underflow will not be as efficient in displacement of slime-bearing water. The fluid already between the jets and this plane cannot escape passing out in the underflow; therefore this slime-bearing water will not be displaced by the hydraulic water. Accordingly the desliming coefficient will be lowered to a much lesser degree. Furthermore, there will exist a maximum amount of hydraulic water that can be efficiently added under such conditions which will be less than that if the hydraulic jets were located at or slightly above the plane at which all liquid passing must report to the underflow. If this maximum is exceeded, the extra hydraulic water merely reports directly to the underflow without performing any effective action. If the rate is still further increased, it will eventually largely destroy the centrifugal force pattern within the cyclone.

A series of tests were made to prove definitely the above hypothesis. Results are reported in Table III. Investigation of the data reveals the following:

1—Slime recovery in the underflow with no hydraulic water was 42.9 pct. With the addition of fresh water, this figure could only be lowered to a probable minimum of 23 to 25 pct, regardless of the quantity of fresh water added.

2—The underflow solid concentration became considerably diluted as excessive amounts of hydraulic water were added. This indicates the direct short-circuiting of fresh water to the underflow.

3—Slime content could be lowered from 16.6 pct to about 8.5 pct, which represents a definite improvement. However, it is not indicative of the better efficiency that could be obtained if the water had been inserted at the correct level. If all data is recalculated on the basis of 55 pct solids concentration in the underflow and the same desliming coefficients, slime content in the underflow would be reduced from 8.3 pct for nonhydraulic water conditions to 2 to 3 pct for fresh water additions. This still does not represent the potential results, as much of the hydraulic water had been inefficiently used.

4—When greater amounts of hydraulic water than reported in Table III were used, the centrifugal force pattern was definitely destroyed. The amount of underflow became very small with almost all solids forced to the overflow. All of these facts definitely point to the correctness of the proposed theoretical cyclone flow pattern. They also emphasize again the need for correct location of the hydraulic water jets as well as good cyclone design.

The location of the hydraulic water jets can be quickly calculated and best demonstrated by a simple example. Suppose that it is desired to feed a cyclone 100 gpm of feed slurry, 20 gpm of which will issue from the underflow with no hydraulic water additions. The actual volume of water and slimes in this underflow could easily be calculated or measured in the real case, but it will be assumed for simplicity that it is equal to 50 pct of the underflow volume. Thus it would be desirable to add up to 10 gpm of hydraulic water to replace the required amount of slime-bearing water in the underflow to obtain a sufficiently deslimed product. If the same underflow solid concentration is to be maintained, the new volume split to the underflow for 10 gpm of hydraulic water will be $\frac{20}{100 + 10} \times 100 = 18.2$ pct. Thus the hydraulic water jets should be placed at least 18.2 pct of the distance between overflow and underflow away from the latter nozzle. It

Table III. Summary of Results, Hydraulic Water Cyclone Tests

	Run 45	Run 46	Run 47	Run 48	Run 49
Feed pressure, psi	4¼	4½	4¼	4⅜	4
Feed slurry rate, gpm	116.4	102.1	93.0	107.9	99.2
Hydraulic water rate, gpm	40.3	21.3	0	24.0	16.9
Overflow rate, gpm	66.7	62.4	49.0	66.8	57.1
Underflow rate, gpm	90.0	61.0	44.0	65.1	59.0
Feed solids rate, tons per hr	7.10	6.30	5.80	7.37	7.57
Feed solid concentration, wt pct	23.5	23.08	23.0	25.1	28.18
Overflow solid concentration, wt pct	9.20	8.55	8.71	10.59	9.53
Underflow solid concentration, wt pct	22.8	30.2	38.0	31.2	37.96
Total volume to underflow, pct	57.5	49.4	47.4	49.5	50.9
Total water to underflow, pct	54.0	43.1	39.4	43.5	42.7
Total solids to underflow, pct	77.3	77.8	80.7	74.7	81.3
−200 mesh slimes in feed, pct	26.9	28.8	31.3	26.4	22.9
−200 mesh slimes in overflow, pct	88.4	91.3	93.8	80.6	86.2
−200 mesh slimes in underflow, pct	8.9	11.0	16.6	8.1	8.4
Solid recovery in underflow, pct					
+20 mesh	100.0	100.0	100.0	99.5	100.0
20x40	99.6	99.7	99.8	94.7	99.9
40x60	93.7	98.6	98.4	83.2	98.4
60x100	80.5	93.5	95.4	72.8	88.6
100x140	61.8	76.6	87.8	56.7	74.3
140x200	68.9	70.5	77.5	63.3	68.4
−200 coarse solids	74.7	81.3	78.3	74.0	71.3
−200 slimes	25.5	29.6	42.9	22.8	29.8
Desliming coefficient	0.472	0.685	1.087	0.534	0.697
If underflow withdrawn at 55 pct solids					
Removal of −200 mesh slimes, pct	94.3	90.5	80.5	91.1	84.4
−200 mesh slimes in underflow solids, pct	2.1	3.8	8.3	3.3	4.6
Hydraulic water of total feed volume, pct	25.8	17.2	0	18.2	14.5
Hydraulic water of total feed water, pct	29.2	20.3	0	21.5	18.0
Distance from hydraulic jets to underflow / Distance from overflow to underflow x 100	15.6	15.6	15.6	20.6	20.6

would probably be advisable to add 1 or 2 pct to insure against short-circuiting of hydraulic water to the underflow.

Two other points are evident from Table III and observed in the other runs performed. 1—No loss of solids above the top size classification point for no hydraulic water additions was experienced when fresh water was fed to the cyclone. The loss of solids to the overflow below this top size will increase as particle size decreases. However, the loss is relatively small in sizes near the top limit. This is very important, as desirable solid recovery will not be appreciably affected by hydraulic water. 2—Fresh water additions will not lower the amount of feed slurry processed at any cyclone feed pressure. Therefore, cyclone capacity per sq ft of cross-sectional area for slurry handling will remain the same.

Industrial Correlations

A commercial installation of the hydraulic water principle has just been made to deslime a high-quality chemical sand. Contamination must be less than 0.5 pct slimes to meet purity restrictions. A two-stage cyclone process was necessary because of heavy feed solid loading and available pressure drop. Two primary 36-in. diam cyclones were designed to handle 1000 gpm of slurry containing 45 pct solids at 3⅞ lb per sq in. pressure drop. The overflow from these units still contained valuable solids and was accordingly fed to two 30-in. secondary cyclones. Results for the installation are indicated in Table II. It will be observed that practically all sand was recovered by this process, but at an unsatisfactory slime content of 0.62 pct.

Hydraulic water jets were added to the primary cyclones to lower the slime content. Because of fabrication difficulties, the jets could not be added on a plane normal to the cyclone cross-section but rather were placed at calculated points along the slant height of the conical section to achieve a displacement action. A comparison of results before and after is given in Table IV. Slime content in the primary underflow was reduced from 0.6 pct to 0.03 pct, resulting in an increase in slime removal from 82.6 pct to 99.1 pct. The desliming coefficient was lowered to an almost perfect 0.055. When combined with the product from the secondary cones, the resultant slime content was only 0.12 pct.

The results form a striking comparison with the previous gravitational classifying operation employed. Approximately 2000 gpm of fresh water were required to achieve a washed sand that would pass specifications but not equal the hydraulic water results. Furthermore, appreciable quantities of high-value fine sand were lost in the process. With the new method, only a total of 150-200 gpm of fresh water are required to obtain the much-reduced slime content. As indicated in Table IV, 99.1 pct of the sand is also recovered, yielding further economies.

Summary

The feasibility of hydraulic water cyclones has been proved, and desliming coefficients of 0.3 or less are now obtainable. This makes possible the elimination of better than 90 pct of unwanted slimes from the underflow product, and in most cases removal should average above 95 pct. Added advantages are the lesser quantities of fresh water required, when compared with classifiers operating at the same slime removal percentages, and the higher slime content in feed slurries that can be tolerated. This last consideration is particularly important where plants must operate with a closed water circuit or using only a small plant bleed stream. Slime disposal problems will be lessened because of the smaller amount of fluid volume that must be handled.

By the use of hydraulic water additions, the required desliming can be obtained in one piece of equipment without any sacrifice of slurry rate or appreciable loss of desirable solids. Through correct hydraulic water design and application as described in the paper, the operation can be made simple and will require little if any attention.

Table IV. Comparison of Cyclone Desliming Results on Chemical Sand With and Without Hydraulic Water

	Without Hydraulic Water, Per 30-In. Cyclone	With Hydraulic Water, Per 36-In. Cyclone
Feed		
Pressure, psi	3⅞	3⅞
Solids, pct	45.0	45.0
−200 mesh slimes, pct	3.0	3.0
Gpm slurry	962	963
Tons per hr solids	151.2	151.2
Gpm hydraulic water	0	68.0
Overflow		
Solids, pct	10.83	10.50
−200 mesh slimes, pct	20.8	33.8
Tons per hr solids	18.2	18.9
Underflow		
Sol.ds, pct	79.2	77.9
−200 mesh slimes, pct	0.6	0.03
Tons per hr solids	133.0	132.3
Removal of slimes to overflow, pct	82.6	99.1
Desl.ming coefficient	1.0	0.055
Hydraulic water of total water fed to cyclone, pct	0	7.6

Acknowledgments

The author wishes to express his sincere appreciation to the Truax-Traer Coal Co. for the opportunity of performing the required basic experiments. Particular thanks are due R. L. Sutherland of that company for his constant cooperation, sound advice, and patient understanding.

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Measurement and Evaluation of the Rate of Flotation as A Function of Particle Size

by T. M. Morris

THE rate of flotation of solid particles determines the percentage recovery of these particles which can be obtained during a given time interval. It is an established fact that the recovery is greatest in the fine sand size range and falls off on either side of this size range. It is also a fact that the history of the development of concentrating devices has been marked by a desire to recover the small particles: tables were developed to treat material too fine to recover in jigs; flotation recovers material too fine to be recovered on tables. As our ores become more complex and require finer grinding, a greater proportion is in the slow-floating size range. It is therefore of economic importance that the effect of size of particle upon rate of flotation be studied.

Many studies have been made along this line. The present investigation attempts to quantify the rate of flotation by means of a rate equation, and then compares the effect of size upon the rate of flotation. It was found that the flotation rate constant increases with increase in diameter of particle in the size range smaller than the optimum size particle. The flotation rate constant decreases with an increase in diameter of particle in the size range coarser than the optimum size particle. This suggested two different actions taking place, and these are discussed. Suggestions for further work in order to improve the flotation rate of both fine and coarse particles are made.

The usual method of expressing rate is to plot cumulative percent recovery vs time. If we knew the equation of this kind of curve we could replot it as a straight line, and the slope of the line would be an index of the magnitude of the flotation rate. It is easier to compare straight lines than curves.

The basis used for obtaining the equation of the recovery vs time curve is the law of mass action. This law states that the "rate of a chemical reaction is proportional to the 'active masses' of the reacting substances present at any given time." This, of course, implies a constant temperature. We can modify this for our use by using the term *flotation reaction* instead of *chemical reaction* and the term *floatable particle* instead of *active masses*.

$$\text{Thus } -\frac{dC}{dt} = kC \qquad [1]$$

where C denotes concentration of particles, t denotes time, k denotes a proportionality constant.

If the exponent of C is 1, then we have a first order rate reaction. If the exponent of C is 2, then we have a second order rate reaction.

For a first order rate reaction, we obtain, after integration,

$$k = \frac{1}{t} \ln \frac{C_o}{C_t} \qquad [2]$$

where k is again a proportionality constant and has the dimension of the reciprocal of time.

C_o is the original concentration or weight or percentage of floatable particles.

C_t is the concentration or weight or percentage of floatable particles remaining in the flotation cell after time t.

If all particles of the mineral to be floated were capable of floating we could take C_o as *100* and C_t would be $100 - R$, where R is the cumulative percentage recovery of mineral at time t. But it is not usual for all of the particles to be capable of floating, because of surface oxidation, etc. Therefore, we must introduce a factor x which is the percentage of unfloatable mineral. Hence the first order equation is

$$k = \frac{1}{t} \ln \frac{C_o - x}{C_t - x} \qquad [3]$$

It has been proposed by various workers[1-3] that this equation describes the flotation rate.

More recently N. Arbiter[4] states that a second order rate equation fits the recovery vs time curve more closely than does a first order rate equation. Morris[5] has discussed the evidence presented for this statement. It has been concluded that the first

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Discussion on this paper, TP 3358B, may be sent (2 copies) to AIME before Sept. 30, 1952. Manuscript, Dec. 10, 1951. New York Meeting, February 1952.

Part of the data used in this paper is taken from a thesis submitted by the author in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Missouri, May 1950.

Table I. Results of Test A

Pan	Time, Sec	Cum. Time, Sec	Weight, G Run 1	Run 2	Run 3	Totals
1	20	20	17.4	17.4	18.8	53.6
2	20	40	9.8	10.8	8.0	28.6
3	20	60	6.6	7.2	6.7	20.5
4	30	90	5.9	7.1	8.2	21.2
5	60	150	8.4	7.3	8.7	24.4
Tails			24.7	23.0	22.4	70.1

order rate equation is the more desirable one to use in evaluating the rate measurements.

Experimental Procedure

Four different kinds of tests were made: A. Laboratory batch tests on cleaned concentrate made from Tennessee Copper Co. ore. This concentrate contained pyrite and pyrrhotite. B. A laboratory batch test using metallic copper particles. C. Laboratory batch tests on plant classifier overflow in the Tennessee Copper Co. concentrator. D. Tests on samples from a 10-cell plant flotation machine floating pyrite. Flotation rates for various size ranges were calculated.

In the laboratory tests the general procedure was to remove froth in consecutive intervals, see Table I. For example, froth was collected in a pan for 20 sec from the time the machine was started and the air turned on. The froth was collected in another pan for the next time interval and so on.

The various concentrates and the final tailing were then washed with acetone or ethyl alcohol, dried and weighed. Then each was screened and elutriated, and the ratio $\ln \frac{C_o - x}{C_t - x}$ was calculated for each concentrate and for each time interval; the values obtained were plotted against time. The slope of the straight line gave the k value or flotation rate constant for each size fraction.

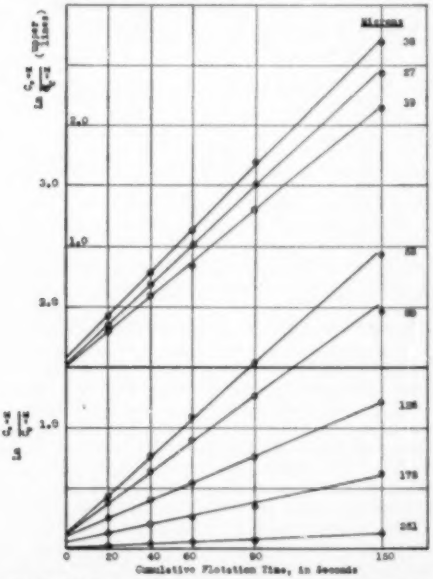

Fig. 1—Variation of flotation rate with average diameter of particle, tests A.

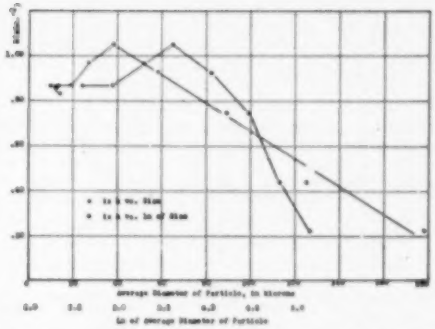

Fig. 2—Variation of k with average diameter of particle and with ln of average diameter of particle, tests A.

In the tests referred to previously under (A), a 250-g mechanical-type cell similar to that described by Dietrich et al.[6] was used. Potassium ethyl xanthate was the collector and terpineol was used as the frother. Sulphuric acid was used to obtain the desired pH of 3.5. Preliminary tests were conducted in which the amount of xanthate used with 75 g of solids was varied. Percentage recovery, of course, increased as xanthate was increased until 37 mg of xanthate were used. Additional xanthate did not significantly increase recovery. It was therefore concluded that when 37 mg of xanthate were used all particles had maximum collector coating.

In the test (B) with metallic copper, the copper was cleaned with nitric acid and washed with distilled water. The particles were very bright and shiny after this treatment. The same cell was used as in the first tests. Sodium aerofloat was the collector, and again the optimum quantity to use was determined by preliminary tests.

The tests (C) on plant classifier overflow were made in the mill laboratory of the Tennessee Copper Co. using a 2000-g Denver machine. The following plant reagents were used: potassium ethyl xanthate, Tennessee Eastman oil as frother, and sulphuric acid for pH control. These tests were made to investigate the effect of the quantity of acid upon the flotation rate of various-sized sulphide particles. In the tests shown the quantity of acid was twice as great in test 2 as in test 1.

In the (D) test on samples of feed, concentrate and tailing were taken from a 10-cell mechanical-type flotation machine. The feed to this machine was a rougher pyrite concentrate. Each product was screened and elutriated and each size fraction was assayed for iron. Recovery was calculated for each size fraction. The calculations for flotation rate constant will be discussed later.

Table II. Size Distribution in Products of Tests A

Mean Diam. Microns	Weight, G Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Tails	k(min^{-1})
251	0.10	0.06	0.05	0.07	0.25	13.30	
178	1.43	0.73	0.56	0.86	1.04	14.16	0.23
136	4.02	2.03	1.53	1.97	2.97	7.52	0.44
89	6.22	2.97	2.24	2.37	2.98	5.87	0.75
58	23.05	10.84	8.13	7.46	8.00	13.31	0.93
38	7.15	4.25	2.77	2.91	2.34	5.06	1.05
27	4.07	2.09	1.92	1.91	1.76	3.67	0.97
19	3.11	2.27	1.21	1.96	1.81	2.65	0.87
13.5	1.73	1.33	0.98	0.97	0.90	1.90	0.87
9.5	0.51	0.56	0.22	0.23	0.33	0.54	0.87
−7.5	0.45	0.33	0.19	0.23	0.25	0.41	

In tests A, C and D the −200 mesh material was elutriated in a Haultain Infrasizer. In test B a long column water elutriator was used, with gelatin as the dispersing agent.

Experimental Results

Tests A: Three tests were run and the respective products were combined for sizing. Table I lists the results obtained. Fig. 1 shows $\ln \frac{C_o - x}{C_t - x}$ plotted vs time for the various sizes. The lines cross the abscissa at minus time, indicating that flotation had started before the air was turned on. This was caused by skin flotation after the xanthate was added and before the air was admitted to the cell.

The k values obtained are listed in the last column of Table II. When these values are plotted against the arithmetic mean diameter of the particles in each size range, Fig. 2 results.

The rate lines for the size ranges 19 and 13.5 microns coincided with the rate line for the size range 27 microns. Flocculation of the finer material in this test may have given this result. Fig. 2 also shows how the k values vary with the natural logarithm of the average diameter of particle in each size range.

Table III. Size Distribution in Products of Test B

Mean Diam. Microns	Solids in Froth, G, After				Solids in Tail, G	k(min^{-1})
	70 Sec	15 Sec	30 Sec	60 Sec		
251	0.033	0.110	0.190	0.090	0.125	1.25
178	0.300	0.265	0.265	0.130	0.350	2.52
126	0.720	0.840	0.570	0.180	0.260	4.27
89	1.910	1.975	1.025	0.190	0.380	4.95
61	3.690	4.075	1.530	0.135	0.380	5.37
53	7.580	6.140	2.320	0.130	0.590	4.90
37.5	3.920	2.550	0.860	0.020	0.190	4.65
26.5	2.445	2.115	0.770	0.035	0.190	3.72
18.7	2.080	3.215	1.480	0.060	0.310	2.88
13.2	1.380	2.080	2.210	0.380	0.470	1.80
10.0	0.580	1.380	2.360	0.940	1.380	

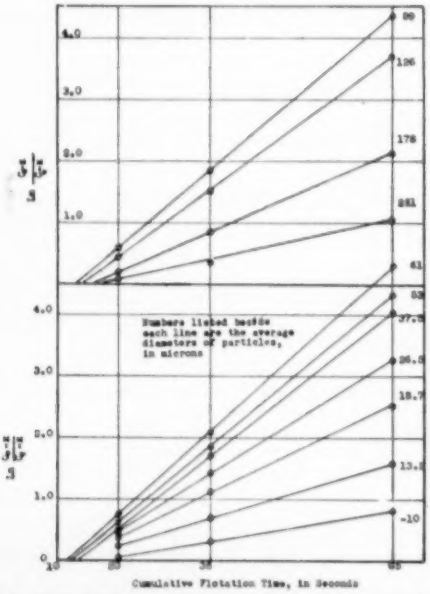
Numbers listed beside each line are the average diameters of particles, in microns
Cumulative Flotation Time, in Seconds

Fig. 3—Variation of flotation rate with average diameter of particle, test B.

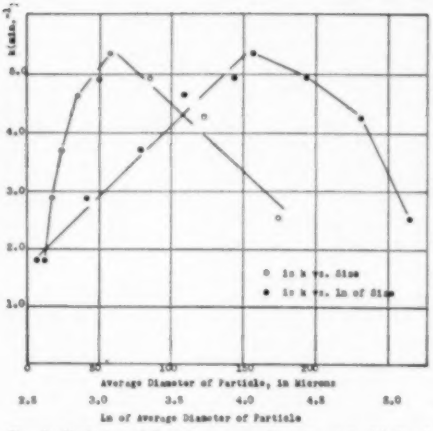

Fig. 4—Variation of k with average diameter and with ln of average diameter of particle, test B.

Test B: Table III shows the sizing results obtained when the concentrates and tails were screened and elutriated. The k values are listed in the last column of this table.

Fig. 3 shows the plot obtained when $\ln \frac{C_o - x}{C_t - x}$ is plotted against time for the various size ranges. The lines intercept the time axis at about 12 sec. This was the time lag from zero time until flotation started. The procedure used for marking zero time was different in tests A and B.

Fig. 4 shows the variation of k with average diameter of particle and also variation of k with the natural logarithm of the average diameter of the particle.

Table IV. Recovery, Pct, in Products of Test D

Mean Diam. Microns	Rec. Fe, Pct	k(min^{-1})
251	93.10	.234
178	98.47	.349
126	99.00	.386
89	99.03	.389
53	99.19	.404
38	98.20	.336
27	96.30	.275
19	94.00	.236
13.5	88.10	.179
9.5	79.90	.135
−7.5	72.50	.100

Test C: For the sake of brevity the data obtained are not tabulated, but Fig. 5 shows the variation of k with average diameter of particle for the two different acid additions in the float. Fig. 6 shows the variation of k with average diameter of particle and also variation of k with the natural logarithm of average diameter of particle.

Test D: Table IV shows the calculated percentage recovery of iron in the 10-cell plant flotation machine for each size fraction. The calculated k values are also shown for each size fraction.

The ratio of concentration of this operation was 1.25, as calculated from iron assays of feed, concentrate, and tailing. No middling was made in this machine. The average time of residence of pulp in

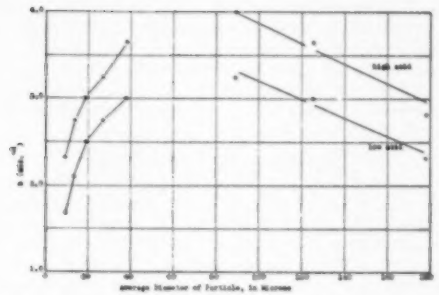

Fig. 5—Variation of k with average diameter of particle, tests C.

the machine was calculated as 12.0 min. This took into account the volume of the machine, and the tons of pulp passing through the machine per unit of time. No great accuracy is claimed for this calculation. In any event an error in retention time would affect all sizes of particles to the same extent; therefore the relative values of k for each size range are valid.

The assumption was made that $x = 0$ since the feed to this cleaner machine consisted of particles which had floated in the preceding rougher operation. This assumption is open to criticism.

The 10-cell machine was regarded as similar to a batch operation in that the concentration of floatable particles in the pulp decreased with time as the pulp passed from the head end toward the tail end of the machine. In a batch operation the concentration of floatable particles in the pulp decreases with time of flotation. In a batch test k can be calculated by using the data obtained in one time interval. By analogy, k can be calculated from the recovery obtained during the retention time of the pulp in the machine, using eq 3, with $x = 0$, $C_o = 100$, $C_t = 100 - R$.

Fig. 7 shows the variation of k with average diameter of particle and also the variation of k with the natural logarithm of average diameter of particle.

Discussion of Results

If eq 3 is applicable to our data a straight line may be drawn through the points obtained when $\ln \frac{C_o - x}{C_t - x}$ is plotted vs time. Fig. 1 illustrates that the first order rate equation may be used to evaluate the rate measurements made in tests A. Additional tests which have been made using the same material used in tests A yield the same results. Fig. 3 contains three points for each line. Although more points are desirable, the metallic copper floated at such a fast rate that it was difficult to obtain three points.

In Figs. 5 and 6 the k value corresponding to the size range of particles obtained in the first cone of the Haultain Infrasizer has been omitted. The k value plots were erratic for this size.

In all of the graphs where k was plotted as a function of particle size the k values for the coarsest fraction and the finest fraction (cone 7 of the Infrasizer) were omitted because it was difficult to assign an average diameter of particle to the coarsest and finest fractions. For the screen sizes the average diameter was taken as the arithmetic mean of the passing and holding screens in each size range. For the elutriated sizes a plot was made of logarithm of cumulative percent passing vs logarithm of size in microns of the sulphide particles in a classifier overflow sample from the Tennessee Copper Co. mill. The equivalent passing screen opening was determined for each cone and the arithmetic mean was taken of the equivalent screen opening of the passing and retaining cone for each size range.

The method used for obtaining the value of x is to use different values of x until the calculated values of $\ln \frac{C_o - x}{C_t - x}$ at the various time intervals lie on a straight line. If the value of x used is too small the later values of $\ln \frac{C_o - x}{C_t - x}$ will lie below a straight line. If the value of x used is too large these later values will lie above a straight line. Small changes in x affect the position of the later values of $\ln \frac{C_o - x}{C_t - x}$ greatly. Therefore x can be determined quite accurately.

It should be emphasized that x is not necessarily the percentage of mineral in the tailing. If the flotation time was prolonged until no more mineral floated, then the tailing assay could be used to determine x. This would assume that no floatable particles were mechanically prevented from being kept in suspension in the pulp. For example, some of the copper particles in test B had deposited on the sloping bottom of the spitzkasten in the cell used and therefore were removed from the zone of bubble-particle contact.

The x value determined in the manner described cannot be greater than the tailing assay obtained after the elapsed flotation time used in the tests; otherwise the method would not agree with actual experimental results.

This method can be checked against the rate plot for the $-100 + 150$ mesh fraction in Fig. 1. The actual cumulative percentage recovery after cumulative flotation time of 90 sec was 47.8 pct. The k value was .44 min^{-1} and the x value used to obtain the straight line was 11. Using eq 3, the calculated cumulative recovery after 90 sec was 48 pct. This is a good check.

Variation of k with Particle Size

The results of all tests show that maximum flotation rate is obtained in an intermediate size range and that the rate decreases on either side of this range. It is difficult to determine whether the flotation rate constant k varies directly with particle size or with the logarithm of particle size on the fine side of the maximum. The results of tests A and C

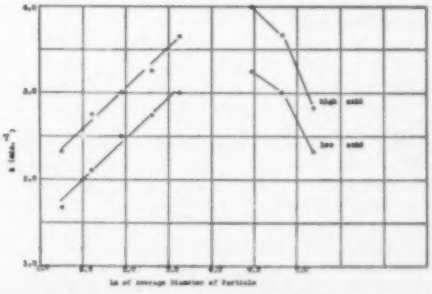

Fig. 6—Variation of k with ln of average diameter of particle, tests C.

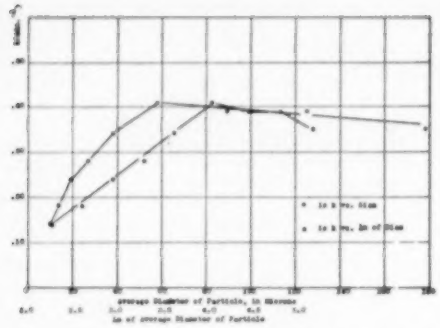

Fig. 7—Variation of k with size of particle and with ln of size of particle, test D.

seem to indicate that the variation is logarithmic, but the evidence is not conclusive. However, on the coarse side of the maximum k seems to vary directly with the size of particle.

Sutherland[7] made a mathematical analysis of the factors entering into the determination of flotation rate, based on the collision theory of bubble-particle union. He derived an equation which predicted that k would vary directly with radius of particle. Thus k would increase as the size of the particle increased, and it is implied that this increase would continue up to the maximum size particle that could be floated.

Gaudin, Schuhmann, and Schlechten[8] investigated the influence of particle size upon flotation rate, using the steady state, and found that specific flotation rate varied with size of particle. They used −40 micron galena and showed that flotation increased as size of particle increased. They deduced that "particles of a size near the maximum that can be floated should have the optimum floatability."

There are two different types of actions taking place in a mechanical-type flotation cell. The first action is concerned with the probability of encounter of bubble and particle. The second action is concerned with the probability of the bubble-particle aggregate reaching the surface of the cell, without disruption taking place between particle and bubble.

Morris[9] measured the forces acting between a bubble and particle under static conditions and found that for any given bubble, the smaller the attached particle, the greater is the probability of the bubble-particle system being able to withstand the disruptive forces present in the flotation cell. Thus the greater is the probability that the particle-bubble aggregate will reach the surface of the cell and be removed.

These two opposing influences of particle size upon flotation rate may be combined as follows to explain the experimental results obtained. The flotation rate increases with size of particle up to the critical size, maximum k value. Before this critical size is reached the probability of union between bubble and particle increases as size of particle increases. This is factor 1. However, the opposing factor 2 is also operating, tending to whittle down the advantage of size. Thus the variation of k with size on the fine side of the critical size is not a straight line, but tends to bend inward as size increases.

When the critical size is reached, any particle coarser than this is not affected or is very slightly affected by factor 1. In other words, the inertia of a particle of this size or larger is enough to enable the particle to make contact with a bubble without being affected by laminar flow or fluid around the bubble. Factor 2 then is dominant for particles larger than the critical size, and the flotation rate could be expected to decrease as particle size increases beyond the critical size.

Suggestions for Further Work

The use of a rate equation provides a valuable analytical tool in evaluating the effect of changes in reagents, impeller speed, type of impeller, and air volume upon the flotation rate of various sizes of particles. For example, in tests C it was demonstrated that increase in acid added to the pulp changed the flotation rate. But all particles were affected to the same extent, as can be seen by the parallel lines in Figs. 5 and 6 when k was plotted vs particle size. The recovery of the fine particles was increased to a much greater extent than was the recovery of the coarse particles, and if recovery alone had been used as a criterion it might have been deduced that increase in acid increased the rate of flotation of fine particles to a much greater extent than the increased rate of flotation for the coarser particles. The reason that the recovery was increased is that the percentage of unfloatable particles was decreased as the acid was increased and the percentage of unfloatable particles was decreased to a greater extent in the fine sizes compared to the coarser sizes.

There is an investigation under way at the Missouri School of Mines pertaining to the effect of impeller speed and volume of air upon the flotation rate of various sizes of particles.

Comparison of different types of flotation machines could be made and evaluated by the use of a rate equation. It appears probable that one kind of machine may yield a higher flotation rate in a given size range than another type. Thus by means of such a study it might be possible to use combinations of different types of machines for the best overall flotation rate. This idea is not new, but study of the possibility could be aided by use of a rate equation.

Acknowledgments

The author is indebted to the following friends and colleagues: Dr. A. W. Schlechten, Chairman, Dept. of Metallurgical Engineering, Missouri School of Mines, for his constructive criticism and encouragement; Mr. J. F. Myers, Superintendent of Concentration, and Mr. E. M. Jones, Superintendent of the Chemical Engineering Dept., Tennessee Copper Co., for permission to use much of the data in this paper and for their constructive criticism; and Mr. William Horst, graduate student at the Missouri School of Mines, for the data used in Tests A.

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The Mobile Drill Unit in Use at the Utah Copper Pit

by L. F. Pett and L. E. Snow

AT the Utah Copper Pit of Kennecott Copper Corp. a versatile mobile drill unit has been developed and tested. Through increased drilling speed and additional available drilling time, an improvement of 233 pct in drill performance has been realized. Operators using drill power can quickly and easily convert the unit from a vertical to a toe hole drill. Drilling is done with the machine in line with the unit or at right angles to it.

Table I covers the 1950 drill record at the mine, showing the types of machines used and the footage obtained.

Table I. Drilling Record for 1950 at the Utah Copper Pit

Type of Hole	Type of Wet Drill Used, In.	Type of Mounting	Total Ft Drilled	Pct	Ft Per Drill Shift	Ft Per Man-Hr
24-ft toe	3½	Tripod	552,411	66	98.7	4.78
28-ft vertical	4	Wagon	250,620	30	127.0	7.94
24-ft bank	3½	Tripod	35,708	4	61.2	2.55
Totals and Averages			838,739		100.7	5.20

Development of the new units was prompted by a desire for solution of the following problems:

1—The ever-expanding operations within the Utah Pit, requiring some 65 miles of transmission pipe lines radiating from a central compressed air plant, have now taxed this compressor plant beyond capacity. While 100 lb per sq in. pressure is maintained at compressors, transmission losses from innumerable small leaks result in low terminal pressure at the drills. Fig. 1 illustrates that while terminal pressure varies according to size of air hose and fittings used, the average drill is operating on air pressures within the 60 to 70-lb range.

The compressor plant is operated primarily for air rock drills. All drilling is done on day shift, but it is necessary to run two of the three 3720 cu ft capacity compressors during night shift in order to prevent drastic loss of pressure through leaks. On day shift all three compressor units are operated at capacity, so that there is no reserve safeguard available for extensive repairs to any compressor. The calculated volume of compressed air required for operation of 25 drills is but 33 pct of three day-shift compressors.

While compressed air is being used to a minor extent for purposes other than drilling, it is felt that satisfactory substitute facilities could be provided in the event that air lines were no longer available.

2—Drill performance has increased beyond the capacity of present 3½-in. drifter machines.

3—The installation, maintenance, and moving of air lines in routine mining is a growing problem. The 2-in. level lines are placed outside electrification towers and must be moved to new location upon completion of each shovel cut. In addition to these moves it is often necessary to dismantle level lines so that excessive shovel spillage, or material covering track following a blast, can be pushed in the clear with bulldozers. Where level room is limited, it is often necessary to remove air lines in giving bulldozers room to prepare grades for wagon drills. In spite of precautions taken, many level lines become buried, twisted, and constricted, with excessive air loss resulting. Excessive back break in blasting often leaves several sections of air line suspended in mid-air. Occasionally air lines come in contact with defective electric transmission towers, so that holes are burned through pipe.

4—Rail-handling of drilling equipment such as wagon drills from one location to another requires considerable locomotive crane crew time. Any new unit developed should travel under its own power.

5—Present practice requires accessory material including hose, water pressure tanks, water barrels, drill steel, and bits to be transported by means of push cars when drill locations are changed on any level.

6—In order to supply numerous drill locations with material, many stock piles of new drill rods, drill bits, and other essentials must be left at strategic points, usually in the vicinity of powder magazines. This practice makes for poor housekeeping and contributes to the loss of supplies.

Planning the Unit

It was felt that a mobile drill unit which would rectify the foregoing problems should meet certain demands:

1—It must furnish compressed air to operate a 4-in. rock drill at a pressure of 90 to 100 lb.

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Discussion on this paper, TP 3352A, may be sent (2 copies) to AIME before September 30, 1952. Manuscript, Dec. 10, 1951. New York Meeting, February 1952.

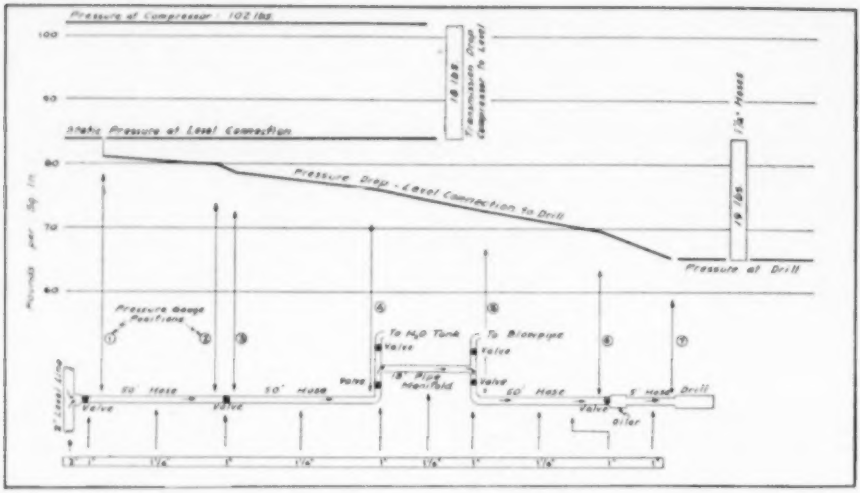


Fig. 1—Air Pressure chart of representative level.

2—It must withstand travel over rough terrain on levels and must negotiate grades on 20 pct bulldozer ramps in moving from level to level. Although ample electric power was available, it was decided that diesel-driven tractors would furnish mobility and be free from interference or dependence upon other mine equipment.

3—The drill mounting must be such that the unit could be quickly converted from a vertical hole machine to a toe hole machine by drill operators and by use of its own power. As a toe hole machine, it must be capable of drilling with the carriage in line with the tractor or, where sufficient clearance is not available for this position, at right angles to the tractor. In this latter position, the tractor is merely moved along the grade between holes, while with the *in line* position, the operator points the tractor in the desired direction of the hole and rides in to a set-up. The in line position would be used in approximately 90 pct of the toe hole drilling, since it places drill and crew farther from falling rocks.

4—The drill must be safer than those used in present operating practice. With either of the toe hole drill positions, operating controls should be placed farther from the collar of the hole than are present machines, to increase the safety of the operating crew. In all cases, the operator must have clearance in getting away from bank caves without climbing around or over drill machinery. The helper on this machine remains away from the collar of the hole, whereas with tripod drilling he was required to spend most of his time near the collar, manipulating the sliding cone and changing drill rods for each 4 ft of hole.

5—The unit should be equipped with a water pressure tank and an ample air receiver and should provide storage for supplies such as extra drill steel, bits, blow pipes, and hose and tool box. A winter cab should be placed on the drill, and heat from the engine and compressor distributed for the convenience of the operator and for the purpose of preventing water in the tank from freezing.

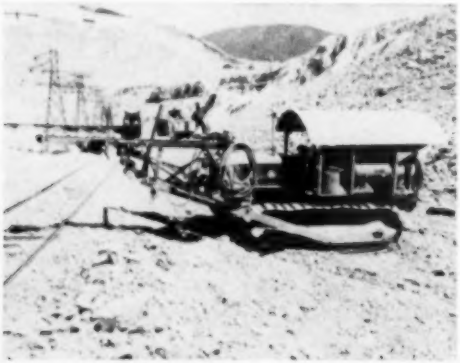


Fig. 2—A D-7 Caterpillar tractor is the primary power unit of the mobile drill rig.

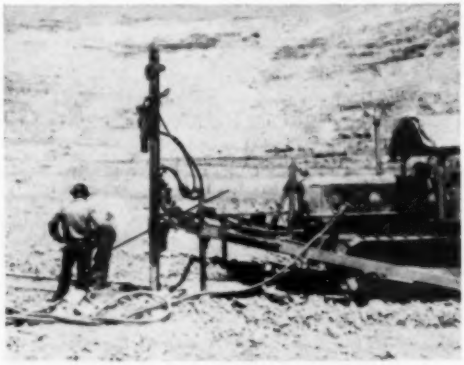


Fig. 3—Mobile drill unit, front end assembly.

Fig. 4—The mobile drill unit in operation.

6—Advance drill grades must be prepared by regularly assigned bulldozers to reduce hand grading.

7—The unit must be equipped with a long drill carriage so that 12-ft steel changes could be made, ground condition permitting.

8—Drill mounting should be equipped with sufficient centralizers to insure drilling straight holes, since it is necessary to insert a 1½-in. loading pipe in springing and loading toe holes.

Construction of the Unit

With the foregoing requirements in mind, the present test machine, shown in Figs. 2-5, was assembled and put into operation on June 24, 1951, in the busiest part of the mine, the bottom section. The assembly job consisted of fitting standard units—tractor, compressor, air and water tanks, drill mounting, and drill adjustments—into a complete mobile drill unit.

Engine: A D-7 Caterpillar tractor, see Fig. 2, was chosen for the primary power unit. This engine furnishes power for moving the unit over the same terrain and ramps used by other mine tractors. It also provides power through the front end take-off for hoisting and lowering of drill assembly in much the same manner that an angledozer blade is raised and lowered. The rear power take-off is used to drive the compressor.

Compressor: A Worthington M-80 two-stage compressor, see Fig. 5, is mounted vertically over the rear power take-off of the D-7 tractor and is driven by nine V-belts. The intercooler is placed directly behind the operator's cab with the V-belt drive at the extreme rear of the unit and covered by a safety guard. Tests of this unit show that with tractor engine speed of 1000 rpm the compressor speed is 875 rpm while the compressor is delivering approximately 294 cu ft of air per min at a 6500-ft elevation. An auxiliary valve is set to maintain pressure in the 90 to 105-lb range. Additional pressure controls within this range are installed to regulate engine speed with compressor demands. The air pressure, while the drill is operating, has remained close to 98 lb. Changes were made in the forced feed oiling system of the compressor, allowing lubricating oil to be circulated while the compressor was on a 20 pct grade. By the disengaging of the rear power take-off clutch, the compressor remains idle while the machine is traveling. Compressed air is piped through a "U" pipe welded into the water pressure tank and then to the air receiver. The water acts as an after-cooler and is heated by the compressed air. This after-cooler is a desirable feature for both winter and summer operation of the unit. A safety valve to prevent steam from building up excessive pressure inside the water tank is installed. A pop-off safety valve is used on the air receiver. An air injector pump quickly fills the water tank from any source of water. From the air receiver air is piped to the front end of the tractor and through a line oiler to the hose coupling for the drill connection. A spud and valve for connecting the blow pipe is provided so that the previous hole can be blown out while the next hole is being drilled. Use of the blow pipe while drilling causes a temporary drop in air pressure to almost 65 lb, but pressure quickly returns to the normal 93 lb upon completion of blowing.

Front End Assembly: The front end assembly, shown in Figs. 3 and 4, is attached to the side frame of the tractor at the same place and in the same manner as are blade attachments on tractor angledozers. This entire assembly is adjusted with the front single drum cable control from the control in the cab or from the drill operating platform. The front end assembly, once in proper position for drilling, is dropped a few inches to an adjustable supporting leg. Tension is maintained on the hoist cable. At the extreme forward position, a 4-in. slotted bar with a double clamp is attached. This allows the drill to slide along the width of the unit in drilling toe holes at right angles to the tractor. While a Worthington drill carriage capable of making 8-ft steel changes was originally installed, experiments with a drill carriage accommodating 12-ft steel changes has improved drill performance. The carriage is mounted on a 7-in. cone. The air motor

Fig. 5—Rear assembly showing Worthington M-80 two-stage compressor.

Table II. Summary of Operations, Mobile Drill Unit No. 1, June 24 to Nov. 1, 1951

Months, 1951	Man-Hr			Ft Drilled			Total Operating Days	Ft Drilled Per Day	Ft Drilled Per Man-Hr	
	2-Man Crew	3-Man Crew	Total	2-Man Crew	3-Man Crew	Total				
June	110		110	2320		2320	7	331.4	21.09	Worthington 4-in. drill, W D 40—2 needles, and 8-ft drill carriage.
July	358	144	502	7448	2326	9774	30	325.8	19.50	
Aug.	163.5	335.25	498.75	2708	4978	7686	25	307.4	15.41	
Sept.	351.25	140	491.25	7369	2190	9559	29	343.4	20.30	
Oct.	304	216	520	7154	3960	11114	28	396.9	21.37	IR-505 and 12-in. carriage, Oct. 13th.
TOTAL	1286.75	835.25	2122.00	27199	13654	40853	119	343.3	19.25	

Average Ft Drilled Per Operating Day		Average Ft Drilled Per Man-Hr	
2-Man Crew	3-Man Crew*	2-Man Crew	3-Man Crew*
323.8	390.1	21.14	16.35

* The third man is added to the operation only when additional hand work is necessary to prepare the grade for drill.

Additional Data

Average air pressure maintained while drilling with 4-in. drill	93 lbs
Cu ft of free air at 1000 rpm on tractor and 875 rpm compressor	294 cu ft
Average diesel fuel used per 8-hr day	18.2 gals
Average lubricating oil used per 8-hr day	0.14 gals
Cable replacements after 4 months' operation	1 cable
Angledozer time charged for preparing advanced drill grades	1.96 hrs per drill shift
Rock drill repair cost after drilling 33,271 ft	$0.0063 per ft drilled

Typical drill speeds in ft drilled per min	12-ft Starter	24-ft Rod	Average
	2.47	2.07	2.27

can be clamped to the drill carriage at any desired position. Besides the drill centralizer at the end of the carriage, an intermediate centralizer is installed to keep drill rods from whipping. A rear leg is used to give additional support to the carriage. For vertical hole drilling, an 11-ft pipe is inserted in the rear support clamps in place of the shorter pipe support used for toe holes.

Winter Cab: The unit has an enclosed cab placed over the tractor seat, with compressor, air receiver, and water pressure tank. A rack constructed alongside the unit provides storage space for additional drill rods and tools.

Machine Performance

The unit, placed in operation June 24, 1951, has with few exceptions been used daily since that time. All minor repairs, adjustments, oil changes and grease jobs have been done at the drill location during regular operating time. Gages showing first stage and final stage air pressure and lubricating oil pressure are placed alongside Caterpillar engine gages within sight of the operator.

In Table II, performance data of the mobile unit is given for 119 operating days. An operating day is considered any day or part of a day during which the drill is used and includes the time for servicing, minor repairs and adjustments, lubrication, and moving from one location to another.

Tests covering 3½-in. and 4-in. drills, as well as 8-ft and 12-ft steel changes, indicate that a 4-in. drill is preferable to the lighter 3½-in. drill and that a 12-ft feed carriage is preferable to an 8-ft feed carriage. This 12-ft carriage is placed on the unit in the same manner as the 8-ft carriage having a 7-in. cone approximately 5 ft from the end-rod centralizer. The extra length of carriage extends alongside the tractor without increasing the overall length of the unit. The 12-ft carriage requires use of only one 12-ft starter drill rod and one 24-ft finisher rod per standard toe hole of 24 ft and provides for machine withdrawal of the drill rod from the bottom of the hole, eliminating considerable hand labor.

The unit has been used only a limited number of days as a vertical hole machine since 50-ft bench heights prevailing in the sub-pit area require few vertical holes. In drop-cutting for a new level, holes angled at a 45° slope have been used. Performance of the unit for vertical hole drilling is as good as in toe hole drilling. In certain fractured ground it becomes necessary to make frequent blowouts with a blow pipe, and under these conditions the unit is slowed down when air pressure drops, as is the case with wagon drills. It requires approximately 30 min for the crew to make the change from toe hole to vertical hole position.

One of the earlier test conclusions proved that it would not be practical to attempt vertical holes exceeding 28 ft in depth because of the reduction of drill speed as this depth is approached. It may be possible, with the improved drilling pattern obtained, to extend the present depth by use of sectional drill rods. It would be an advantage, in 70 and 80-ft banks, to drill 40-ft vertical holes and eliminate bank holes.

Bit Performance on the Tractor Drill

Tests made on bits used on the tractor drill show that bit performance is improved over results obtained with similar bits on drifter or wagon drills. Table III shows results and comparisons.

Table III. Comparison of Bit Performance on Drills, 1950-1951

	1951 Tractor Drill	1950 Drifter and Wagon Drill Average
Average operating air pressure, lbs	93	60-70
Average drill speed, ft per min	2.27	1.17
Total gage loss for 24-ft hole while drilling only, in 32nds of an in.	4.9	9.1
Average footage per bit per sharp use	18.4	10.83
Average number of regrinds possible	2.08	2.32
Number of uses, new and regrinds	3.08	3.52
Total footage per new and reground bit	56.7	38.12

The retarding effect of depth of hole on drilling speeds is such that larger starter bits have greater rate of penetration than smaller finisher bits.

Sufficient sharp bits are placed on the tractor drill at the beginning of the shift and the helper changes bits as needed. Carrying bits on the unit, both sharp and dull, makes for better housekeeping and reduces appreciably the number lost over previous practice.

Drill Rod Performance on Tractor Drill

While insufficient data has been collected to determine the life of new alloy steel rods, it is estimated that approximately 5 drill rods per week are replaced, indicating an average life of 500 ft per drill rod. Some loss of drill steel is anticipated in utilizing broken pieces on longer drill feeds. This may be minimized by using three steel changes in harder ground sections of the mine. This disadvantage is offset by the fact that with two steel changes used on the mobile drill only 36 ft of drill rod are necessary per hole, whereas for 4-ft changes on present drifters 84 ft of drill rod are needed. Reduction in number of drill units and elimination of present level stock piles will reduce steel rod consumption.

During 119 operating days of the unit, the average of feet drilled per 8-hr shift has been 343.3. Based on the 1950 Report of the Drilling and Blasting Department, which shows 838,739 ft drilled annually, 2300 ft per day, the mobile drill performance represents approximately 1/7 of the total mine drill since it was put in service.

Table IV compares the mobile drill with the 3½-in. drifter and 4-in. wagon drill in the same subpit area of the mine.

Table IV. Comparison of Drill Performances

	Ft Drilled	Ft Per Drill Shift	Ft Per Man-Hr	Cost Per Ft of Hole, $
1950 subpit record, drifter and wagon drill	350,000	111.9	8.78	0.301
Mobile drill average on same footage	350,000	343.3	19.25	0.090
Difference in favor of mobile drill		231.4	13.47	0.209

An estimated annual saving of $73,000.00 in drill labor could be achieved by using three mobile drills to cover the subpit area of the mine.

Photoelectric Sorting of Optical Fluorspar

by W. T. Turrall and D. Porter

The paper describes a machine developed for the purpose of concentrating clear optical grade fluorspar crystal from a feed material containing less than 1 pct impurities. The principle of concentration is based on the fact that in a liquid having an index of refraction equal to that of fluorite (n — 1.434) clear crystals are invisible, whereas crystals containing occluded impurities absorb a part of the light. As the crystals pass through a light beam, undesired crystals give themselves away by creating a shadow on a photoelectric receiver. The shadow is converted by the photoelectric cell into an electric pulse. An electronic circuit amplifies this pulse and commands the operation of a mechanical concentrator.

THE crystal laboratory, Dept. of Physics, Massachusetts Institute of Technology, was confronted with the problem of obtaining a supply of optical grade calcium fluoride (CaF_2) for use in growing synthetic CaF_2 crystals. A search of the known fluorspar deposits did not indicate that any quantity of optical spar could be obtained. Even the best material had to be sorted by hand to remove impurities.

The process for growing CaF_2 crystals developed by Professor D. C. Stockbarger of the Dept. of Physics, M.I.T., necessitates very pure feed materials. Exclusion of impurities is required, even in amounts detectable only spectrographically. The impurities occurred as minute inclusions of SiO_2, $BaSO_4$, $CaCO_3$, FeS_2, water or air. Crystals up to 4 in. in diam and weighing several pounds are made by the Harshaw Chemical Co. in Cleveland. Since the time required to grow a 4-in. crystal is about one week, and since the cost of manufacture is high, removal of impurities by any concentration method appeared practical.

The mineral engineering section of the Dept. of Metallurgy undertook to investigate the possibility of concentrating clear optical fluorspar, —4 mesh +10 mesh, from a feed containing over 99 pct CaF_2. Various innovations of the known methods of concentration were considered, but in each case the minute amount of impurities associated with the crystal produced such extremely small differences

W. T. TURRALL, Member AIME, formerly Assistant Professor of Metallurgy, Mineral Engineering Section, Massachusetts Institute of Technology, is now Supervisor and Technologist of Coal Preparation, Lehigh Navigation Coal Co., Lansford, Pa. D. PORTER is a student, Dept. of Physics, Massachusetts Institute of Technology.

Discussion on this paper, TP 3351B, may be sent to AIME (2 copies) before Sept. 30, 1952. Manuscript, March 15, 1951. St. Louis Meeting, February 1951.

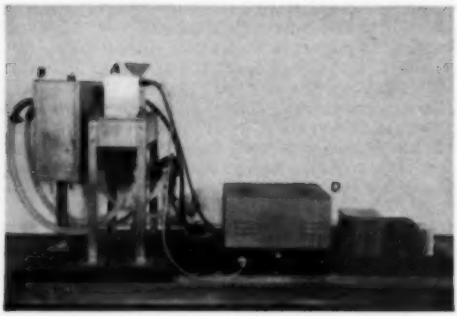


Fig. 1—Photograph of photoelectric concentrator showing: A. Housing for exciter lamp, phototube, sorting column, and gate mechanism; B. Product container; C. Variac and pump for liquor circulation; D. Electronic unit with adjustable sensitivity control and exciter lamp power supply.

in physical properties of the particles as to eliminate the usual methods of mineral concentration.

Since the concentrated product was to be used for its optical properties, it was decided to explore the prospects of developing a photoelectric concentrator, utilizing as the fundamental basis of separation optical differences between those particles which were clear and those which were not.

Principle of Photoelectric Concentration

Photoelectric concentration of fluorite is based on the fact that in a liquid having an index of refraction equal to that of fluorite ($n = 1.434$) clear crystals are invisible, whereas crystals containing occluded impurities absorb or scatter a part of the light. Thus if crystals pass through a horizontal light beam, the undesirable crystals give themselves away by changing the light received by a photoelectric receiver. This change in light flux is converted by the photoelectric cell into an electric pulse. An electronic circuit amplifies this pulse and commands the operation of a mechanical gate. The essential parts of the concentrator are: 1—a sorting tank filled with optical liquor (toluene in ethanol), 2—a beam of light at right angles to the path of the particles, 3—a photocell and an electric amplifier, 4—a gate or flipper to guide the particles into one compartment or another of the sorting tank, and 5—a pumping system to facilitate the collection of particles in their respective product baskets.

The first model, constructed of lucite, was essentially an exploratory machine and as such contained many gadgets, but it served its purpose in developing an electronic circuit, indicating necessary changes, and proving the approach feasible. Figs. 1 and 2 show the completed machine with its electronic control.

A feeder was designed to present sized particles to the horizontal light beam one at a time. The feeder employs vacuum to pick up particles on the end of radial nozzles connected through a control valve to the main vacuum tank. The control valve permits each particle to stick to the nozzle for about $\frac{3}{4}$ of a turn, and since the driving shaft is horizontal, it allows the feeder to pick particles up from a supply layer and deliver them in regular sequence as bodies falling in a viscous fluid across the beam of light.

The sorting column is $\frac{3}{4}$ in. wide and square in cross section. Its length is about 5 in. It has been found advisable to use hoppers with discharge openings of several sizes, so that each opening permits the passage of some particular size of particles. In this way the particles can be centered through the sorting column and are sorted when in the same position with respect to the beam of light. To facilitate adjusting and cleaning of the concentrator, the sorting column and all mechanical parts are built into the removable top of the product compartments. The sorting column is centrally located above an adjustable dividing bar between the compartments into which the crystals fall. At the bottom of the column are deflecting gates mechanically operated by a small reversible motor through a train of gears.

On being deflected to their proper compartment, the particles settle to the bottom and discharge through an opening into the pumping system, see Fig. 3. The liquor transports the particles into removable concentrate and reject basket containers, or product baskets. These have bottoms of 14-mesh copper screen and are fitted in the upper compartment of the product container, unit B in Fig. 1.

The product container is divided into an upper and lower compartment so that as the products are collected in the baskets solution height in the system is kept constant by allowing displaced solution to overflow into the lower compartment. The solution can be drained readily and returned to the pumping system after the products have been removed. It is important to maintain a constant solution level in the sorting column; otherwise a change in settling

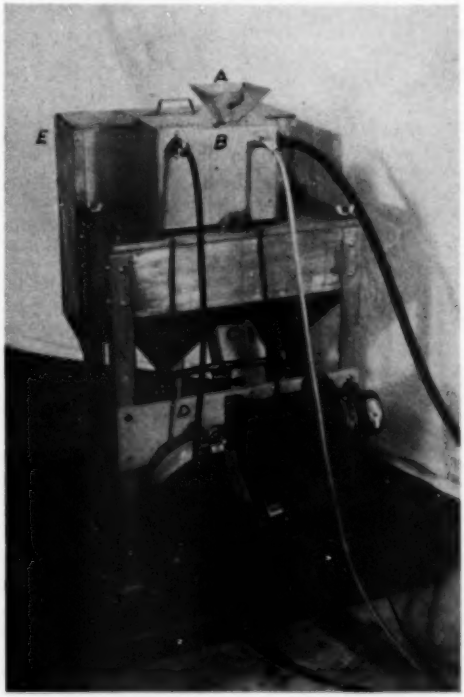
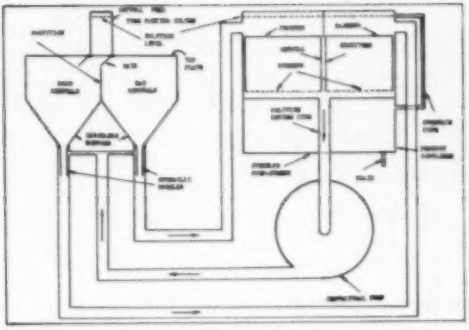
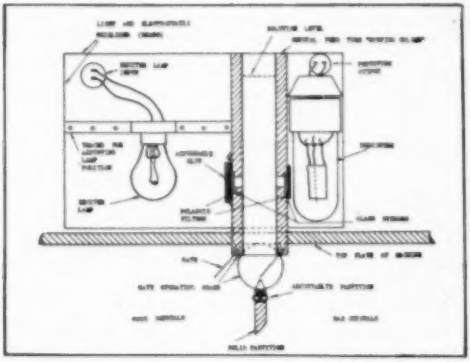


Fig. 2—Photograph of photoelectric concentrator showing: A. Feed hopper; B. Housing for exciter lamp, phototube, sorting column, and gate mechanism; C. Discharge hoppers; D. Pumping system; E. Product container.





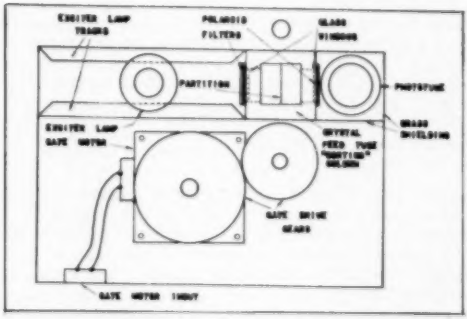


Fig. 3—Diagram showing flow of optical liquor. Fig. 4—Optical system with portion of gate mechanism illustrated. Fig. 5—Plan of optical system, gate motor, and gate driving gears. Fig. 6—Diagram of exciter lamp power supply.

time of particles can be troublesome once the feed rate and the electrical time delay of the gate mechanism have been synchronized.

A small centrifugal pump controlled by a variac, unit C in Fig. 1, is used to circulate the liquor. Particles do not pass through the pump but are impelled by the flow as the solution is forced through nozzles located at the discharge of the product hoppers. As can be seen in Fig. 3, the liquor, carrying the products, passes through the screen in the product baskets and returns to the pump. By utilizing such a flow system, it is possible to obtain constant circulation of liquor for transporting purposes and also to maintain the liquor in the crystal-sorting zone in the state of quiescent pool. This condition eliminates interference with the settling of the crystals. Tygon tubing is used to make connections in the pumping system, the machine proper being of brass construction.

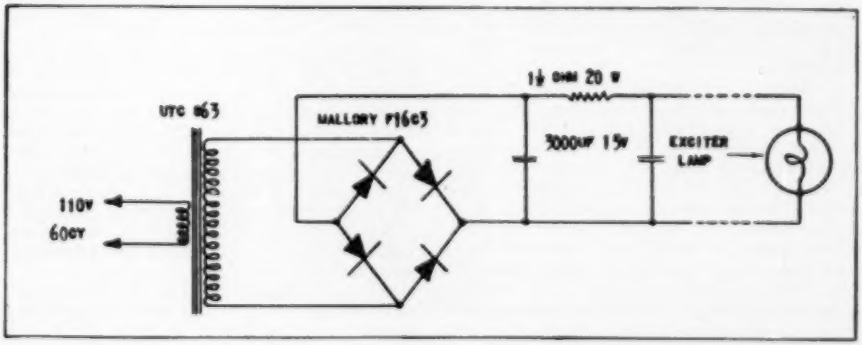
The Optical and Electronic System

The optical system employed in this machine, see Figs. 4 and 5, is relatively simple. It consists of glass windows mounted in opposite sides of the sorting column and backed by two crossed polaroid filters to provide dark-field illumination. An exciter lamp having an input of 6-v direct current is used as the light source. It is mounted on tracks so that its distance from a phototube located directly opposite can be varied. This adjustment permits a variation in the excitation of the phototube.

The amount of light permitted to pass through the optical liquor is controlled by an adjustable slit placed in the optical path. The variation in the light flux evaluated by the phototube depends in part on the size and in part on the opacity of the passing particles. The rate of change of the light flux determines the rise time of the pulse delivered by the phototube.

The purpose in using polaroids in the light path is to provide a system in which virtually no light strikes the photocell when a perfect crystal is interposed, whereas an appreciable light flux reaches the photocell when an imperfect crystal is interposed and depolarizes the light. This gives a very large proportionate increase in light flux when an imperfect crystal passes. If dependence is placed on the use of ordinary light instead of polarized light the variations in flux on a percentage basis are very small.

The electronic system may be referred to as the brain of the concentrator. When it receives a signal



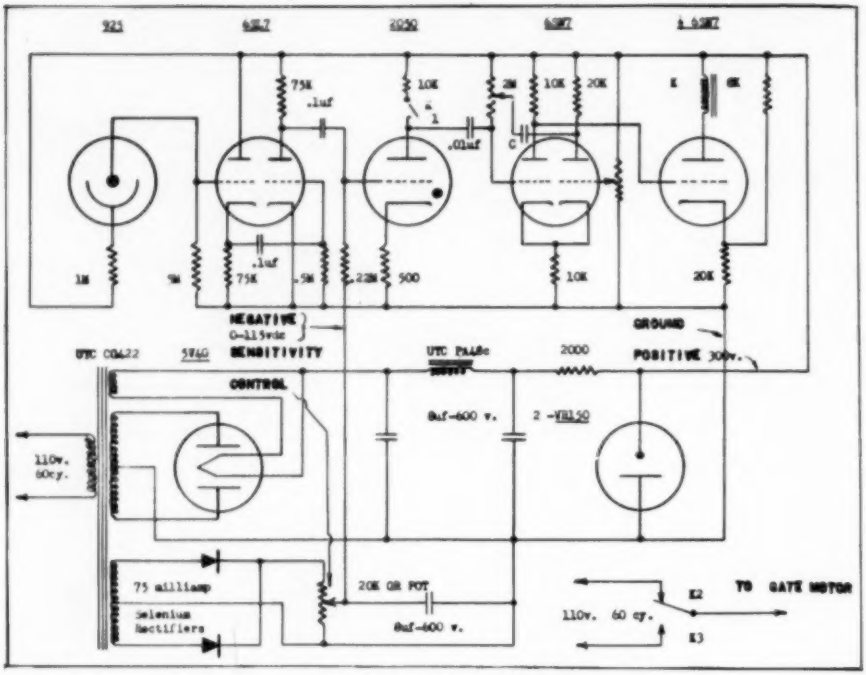


Fig. 7—Diagram of electronic circuit.

from the phototube as an undesirable particle is passing through the sorting column, the signal is amplified to operate a relay which energizes the deflecting gate mechanism for a specified duration of time. The magnitude of light pulse which will cause action is referred to as the *threshold*. This threshold is adjustable by a control known as the *sensitivity control*. In operation, therefore, it is this control which is the regulator for the purity of the concentrate. It should be understood that the gates are normally at rest in the "good" position so that particles which contain no impurities will have passed into the discharge hopper before the next particle is presented to the light beam. The length of time the gates stay closed when an undesirable particle is to be rejected depends on the settling velocity of the crystals through the liquor and the distance between the beam of light and the gates. Because of mechanical inertia of the gate system, the maximum repetition rate for one cycle of operation is about 0.8 sec. To allow for possible discrepancies in settling rate due to shape and size, the particles are fed to the machine at the rate of about one every 1.5 sec.

It is not the purpose of this paper, however, to discuss the electrical circuits in detail. Wiring diagrams of the exciter lamp power supply and electronic system, Figs. 6 and 7, respectively, are included to show the basic requirements.

An attempt was made to determine the efficiency of the machine by quantitative spectrographic analyses of the feed, concentrate, and reject. No significant differences were obtained by this method. This is because there was an extremely small concentration of noxious impurities in all products and also because some of the undesired constituents were anions and did not show up in the spectrographic analyses. The answer was provided by growing small crystals using material representing the feed and material representing the concentrate. The concentrate produced a clear synthetic crystal, whereas the feed did not.

Summary

The photoelectric concentrator provides a method for sorting high quality optical fluorite crystals. Although each crystal has to be examined individually by the apparatus, the process is continuous. The sensitivity of the electronic circuit is such that it rejects those crystals which to visual examination appear to be unsatisfactory. It is realized that such a device will have limited application and will be used only for the solution of problems where tonnage and cost are not critical factors.

Acknowledgments

The writers are greatly indebted to Professor A. M. Gaudin, Mineral Engineering Section, Dept. of Metallurgy, MIT, for his continued encouragement in this interesting and challenging research and for his suggestions in the editing of this paper. The writers also wish to thank Professor H. Rush Spedden of the Mineral Engineering Section, Dept. of Metallurgy, and Professor D. C. Stockbarger, Dept. of Physics, for their constructive criticism during the development of the machine. To H. A. Lundquist, Dept. of Physics, much credit is due for the mechanical success of the machine.

This work was made possible by the support given by the Harshaw Chemical Co. to the crystal laboratory of the Physics Dept. at M.I.T.

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aime NEWS

Los Angeles To Play Host For 1953 Annual Meeting

Los Angeles may well be host to one of the most historic gatherings of AIME members Feb. 16 to 19, 1953, when the 175th General Meeting is scheduled to take place. Plans in the formulative stage indicate that the meeting will be one of the largest ever held by AIME.

Headquarters will be the Hotel Statler, now nearing completion of construction. The hotel will be one of the most modern hostelries of the century. The first technical session, of which there will be more than 75, will take place Monday, February 16. Mineral Industries Education Div. and the Board of Directors meet Sunday, February 15. Sessions will end with a meeting of the Council of Section Delegates on Thursday.

Deadline for papers that may be preprinted for presentation at the meeting is Sept. 15, 1952. However, division program committees may list papers for presentation after that date if they choose.

Various committees are engaged in formulating final plans for the meeting. Developments will be announced as progress is made.

Bylaws Amendment On Dues Proposed

At its meeting on July 16, the Executive Committee proposed that the first two sentences of Article II, Section 2 of the Bylaws of the Institute be revised to read as follows, provided the referendum of the membership votes to give the Board its authority. The Board will vote on this amendment of the Bylaws at its meeting on September 7: "Until otherwise determined by the Board of Directors of the Institute, the dues of Members and Associate Members shall be $20 per annum, and dues of Junior Members shall be $12 per annum for the first six years of membership and thereafter $17. Dues shall not be required of either Honorary or Senior Members."

AIME Fall Meeting Coincides With Engineering Centennial

The windy, convention city of Chicago will act as host to the Fall Meeting of the Institute and the celebration of 100 years of engineering progress. AIME meetings will be held primarily at the Palmer House, Sept. 3 to 13.

Sixty-one societies from the United States, Europe, and Latin America will take part in the centennial, which serves as the theme for all meetings.

Industrial Minerals Div. and Minerals Beneficiation Div. are holding their regular fall meetings in Chicago. Mining and Geophysics subdivisions are scheduled to participate in joint programs with the IMD and Geology sessions. The Coal Div. is expected to present a varied technical program on mining and utilization of coal.

The Chicago section will play host to the Institute at a dinner Friday evening, Sept. 5. The Red Lacquer Room of the Palmer House will be the scene of a dinner-dance, formal close to the Institute's activities at the centennial celebration.

Mankind's advance from caves to skyscrapers will be dramatized by a musical show "Adam to Atom." It will show man's progress through utilization of engineering and scientific achievements. The show began its run July 12 and will continue through the summer season.

Feature of the IMD session will be an industrial ground water supplies symposium, which will include seven important papers in various phases of exploration and exploitation. Field trips to areas of operation around Chicago are scheduled for the two days prior to the beginning of formal meetings. The Friday session of IMD will cover advances in industrial minerals and building materials in the Chicago area.

Minerals Beneficiation is slated to hold an all-day session Friday, Sept. 4, in the form of a symposium on the concentration of low grade iron ores. It will cover all aspects of beneficiation of iron from structural features affecting concentration to pelletizing.

Brown Iron ores and the activities of state geological surveys will be the material for the symposium constituting the program of the Geology Subdivision. *(Program on page 808)*

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Chicago Centennial Program

WEDNESDAY, SEPTEMBER 3

8:30 am — Registration — Palmer House
Foyer of Club Floor

Minerals Beneficiation Div.

THURSDAY, SEPTEMBER 4

10:00 am — Room 17 — Palmer House

F. X. Tartaron and S. E. Erickson Associate Chairmen:
Concentration of Low Grade Iron Ores

Structural Features Affecting Concentration of Iron Ores: F. Talonen, N. H. Manderfield, and P. Jasberg, Michigan College of Mines and Technology.
Mineralogy of Michigan Taconites: F. X. Tartaron, Jones & Laughlin Steel Corp.
Processing Magnetic Type Taconites (motion picture): Minnesota Mines Experiment Station.
Cyclone for Heavy Media Concentration of Iron Ore Fines.
Results from a Spiral and Flotation Pilot Plant Treating Low Grade Iron Ore.

THURSDAY, SEPTEMBER 4

Luncheon
12:30 pm — Room 18 — Palmer House
E. H. Crabtree, Jr., Div. Chairman

Luncheon to be followed by brief business meeting

THURSDAY, SEPTEMBER 4

2:00 pm — Room 17 — Palmer House

R. E. Powers and J. L. Lake, Associate Chairmen

Mineral Constituents of Sinter: H. M. Craner, Bethlehem Steel Co.
Vacuum Extrusion of Slugs: Franklin C. Senior, H. A. Brassert & Co.
Pelletizing of Iron Ores: Louis Erck, Cleveland Cliffs Iron Co.

FRIDAY, SEPTEMBER 5

9:00 am — Room 17 — Palmer House

Neil Plummer and D. P. Hale, Jr., Associate Chairmen

Performance of Large Rod Mills of Consolidated Mining & Smelting Co.
Performance of Commercial Installations of Aerofall Mills: Staff, Aerofalls Mills, Ltd.
Correlation of Microstructure of Ball Mill Rods with Rate of Wear.

FRIDAY, SEPTEMBER 5

2:00 pm — Room 17 — Palmer House

Nathaniel Arbiter and Oscar F. Tangel, Associate Chairmen

Conductivity Study of Mineral Suspension: Shiou-Chuan Sun and E-an-Zen, Pennsylvania State College.
Magnetic Reflux Classifier: Lawrence A. Roe, Bjorksten Research Laboratories, Inc.

Industrial Minerals Div.

WEDNESDAY, SEPTEMBER 3

Field Trip, Indiana Dune Sand State Park

Field trip conducted by Indiana Geological Survey, Ned Smith in charge. Party leaves Palmer House at 12:30 pm by chartered bus and will visit operations of the Grisman Sand Co., Nanley Sand Co., and Bos Sand Co. A stop will also be made at the Indiana Dune Sand State Park, affording an excellent opportunity to observe the interesting geologic features of the Tolleston and Calumet dune and beach deposits. Return to Chicago in time for a late dinner.

THURSDAY, SEPTEMBER 4

Field Trip, Ottawa and Goose Lake Areas

Field trip conducted by the Illinois Geological Survey, J. E. Lamar in charge. Party leaves Palmer House at 8:00 am by chartered bus for the plant of the Standard Silica Corp. at Ottawa, about 90 miles west of Chicago. Here they will see open-pit hydraulic mining and underground hydraulic mining of silica sand from the St. Peter formation, processing of the sand into various grades of industrial sands, and grinding of the sand to make ground silica.

The next stop after Ottawa will be the plant of the Illinois Clay Products Co. at Goose Lake, near Joliet, where a box car cafeteria-style luncheon will be served through the courtesy of the company. In the afternoon the party will visit the company operations and will be shown the selective mining of refractory fire clay for the metallurgical industry and of illite clay for bonding clay, the manufacture of Zonolite insulating brick and plaster, the burning of ladle brick in tunnel and beehive kilns, and the making of chemically bonded refractory brick. Return to Chicago by 7:00 pm.

FRIDAY, SEPTEMBER 5

9:30 am — Red Lacquer Room — Palmer House

N. M. Leighton and G. J. Biddle, Associate Chairmen

Advances in Industrial Minerals

Trends in Great Lakes Bulk Transportation of Nonmetallic Materials: Oliver T. Burnham, Lake Carriers Assn.
Coal Movement into the Chicago Area: Walter Voskuil, Illinois Geological Survey.
Development of the Cement Manufacturing Technology During the Past Century: Jens C. Holm, Marquette Cement Mfg. Co.
Underground Mining Silica Sands by Hydraulic Methods: A. D. Bryant, Standard Silica Corp.

FRIDAY, SEPTEMBER 5

Luncheon
12:15 pm — Red Lacquer Room — Palmer House

Ian Campbell, Chairman

A brief business meeting will follow the luncheon

FRIDAY, SEPTEMBER 5

2:00 pm — Red Lacquer Room — Palmer House

Thomas Murphy and Bror Nordberg, Associate Chairmen

Advances in Building Materials

Engineering Research in Structural Clay Products:

Paul V. Johnson, Structural Clay Products Institute.
Developments and Users of Light Weight Aggregates: Albert Litvin, Armour Research Foundation.
Developments in Aggregate Production in the Past Fifteen Years: S. T. Harrison, J. L. Shiely Co.
Light Weight Aggregates in the Chicago Area: William Jackson, Silbrico Corp.
Major Nonmetallic Mineral Building Material Industries in Metropolitan Chicago: Kenneth A. Gutschick, Material Service Corp.

FRIDAY, SEPTEMBER 5

Executive Committee, Industrial Minerals Div.

5:00 pm — Red Lacquer Room — Palmer House

SATURDAY, SEPTEMBER 6

9:00 am — Red Lacquer Room — Palmer House

Ground Water in Industry

(In participation with the American Assn. for the Advancement of Science)

A Geophysical Investigation of Glacial Deposits near Anderson, Ind.: Maurice Biggs and William J. Wayne, Indiana Geological Survey.
Application of Sound in Mapping Bedrock Surfaces Beneath Sediments: William O. Smith, USGS.
Geology of Industrial Groundwater Supplies in Illinois: Frank C. Foley, Illinois Geological Survey.
An Application of Interference Methods to a Problem of Brine Disposal in the Dundee Formation of the Michigan Basin: John Ferris, USGS.
Recharge Operations of the Duhernal System near Spotswood, N. J.: Gordon E. Linn, Duhernal Water System (Open discussion period, all authors participating).

SATURDAY, SEPTEMBER 6

2:00 pm — Red Lacquer Room — Palmer House

Ground Water in Industry (Continued)

Industrial Application of Groundwater Recharge by Wells: M. L. Broshears, Legette & Broshears, consulting groundwater geologists.
Large Industrial Water Supplies by Induced Filtration: Fred H. Klaer, Jr., Ranney Method Water Supplies, Inc.

Geology Subdivision

FRIDAY, SEPTEMBER 5

2:00 pm — Room 14 — Palmer House

Symposium on Brown Iron Ore Resources

Brown Iron Ore Resources of Alabama: Walter B. Jones, state geologist.
Brown Iron Ore Resources of Georgia: Garland Peyton, director, Dept. of Mines, mining and geology.
Brown Iron Ore Resources of Southeastern Minnesota: Alfred E. Boerner, geologist, M. A. Hanna Co. and George M. Schwartz, director, Minnesota Geological Survey.
Brown Iron Ore Resources of Texas: John T. Lonsdale, director, Bureau of Economic Geology.
Brown Iron Ore Resources of Missouri: Edward L. Clark and Garrett A. Muilenburg, Missouri Geological Survey.
A Regional Summary of Brown Iron Ore Occurrences, Production and Utilization: Arthur J. Blair, consulting geologist.

SATURDAY, SEPTEMBER 6

(Joint Session with Mining Subdivision)

9:00 am — Palmer House

Activities of the State Geological Surveys

Minnesota Geological Survey: George M. Schwartz, director.
Geological Survey, Div. of the Michigan Dept. of Conservation: Franklin G. Pardee, chief of Geological Survey Div.
Illinois State Geological Survey: N. M. Leighton, chief.
Indiana Div. of Geological Survey: Charles F. Deiss, state geologist.
Div. of Geological Survey, Dept. of Natural Resources, State of Ohio: John H. Melvin, div. chief.
Activities of the USGS in the Great Lakes Region:

SATURDAY, SEPTEMBER 6

Mining Subdivision

Joint Program Geology Subdivision

Geology Subdivision

Joint Program Industrial Minerals Div.

SATURDAY, SEPTEMBER 6

Luncheon Meeting, Mining, Geology and Geophysics Div.

12:15 pm — Room 18 — Palmer House

LeRoy Scharon, Division Chairman, Motion picture

Iron and Steel Div.

FRIDAY, SEPTEMBER 5

2:00 pm — Crystal Room — Palmer House

Developments in Steel and Steel Alloys in the Last Century: Elmer Gammeter, chief metallurgist, Globe Steel Tubes Co., Milwaukee, Wis.

E. C. Bain will be the principal speaker at the meeting of the Chicago Section, AIME at 6:30 this evening.

Coal Div.

FRIDAY, SEPTEMBER 5

2:00 pm — Room 18 — Palmer House

Evaluation of Coal Properties in the Field: E. C. Dapples, professor geology, Northwestern University.
Methods Used in Recent Compilation of Coal Resources of Illinois: J. A. Simon, Illinois Geological Survey.
An Analysis of Estimating National Coal Reserves Based on Nation-wide Survey of Synthetic Liquid Fuel Potential of the United States: Clayton G. Ball, Paul Weir Co.

SATURDAY, SEPTEMBER 6

9:00 am — Crystal Room — Palmer House

Effect of Water-borne Industrial Wastes on Stream Pollution: Henry F. Hebley, research consultant, Pittsburgh Consolidation Coal Co.
Developments in Auger Mining: W. R. Hennessey, Cardox Corp.

FRIDAY, SEPTEMBER 5

Chicago Section, AIME

6:30 pm — American Bar Assn. — Equitable Bldg.

W. E. Mohin, Chairman

Dinner followed by regular monthly meeting.
Speaker, E. C. Bain, vice-president, research and technology, U. S. Steel Co.

SATURDAY, SEPTEMBER 6

AIME Dinner Dance

7:00 pm — Red Lacquer Room — Palmer House

SUNDAY, SEPTEMBER 7

Meeting of AIME Board of Directors

2:00 to 5:00 pm — Crystal Room — Palmer House

THE DRIFT OF THINGS

by Edward H. Robie

Dues to Continue Unchanged

SUBJECT to formal Board approval in September, AIME dues will continue indefinitely at the present scale of $20 for Members and Associate Members; and $12 for Junior Members for the first six years of such membership, thereafter $17. That is the wish of the Board of Directors and the will of the membership, as expressed in the recent referendum.

Though the official returns, as reported by the tellers, are not available as this is written, the data are sufficiently complete to give the results to the nearest percent. The total vote was approximately 93 pct for continuance of the present scale. Metals Branch members voted about 94 pct for continuance; Mining Branch members slightly less than that; and Petroleum Branch members about 91 pct. As in the referendum of 1949, there was no particular difference of opinion on the question of dues as between the three Branches.

The percentage of ballots returned was about 61 pct, only slightly more than in the 1949 referendum. But the affirmative vote was much greater, 93 pct against 78 pct in the earlier referendum. Looked at another way, a majority of those to whom ballots were sent, 56 pct, voted to continue the present scale of dues, whereas only 46½ pct of those canvassed voted to raise the dues in the previous referendum.

But approximately 600 members expressed their opinion that the dues should go back to $15 for Members and Associate Members and to $10 and $15 for Junior Members. This is a substantial group of members who either do not think they are getting their money's worth from AIME membership, or believe that a more businesslike conduct of Institute affairs should provide current services at less cost, or believe that more service is being provided for their dues than they need. As to the first point, it is probable that some members are not getting their money's worth. They perhaps have only a fringe interest in AIME activities, or they do not or cannot participate in such activities at the Local Section, divisional, or national level, so that all they get out of the Institute is the monthly journal, which they do not have time to read. If they did read it intelligently, and acted upon the professional information thus gained, it is difficult to understand how one or more ideas cannot be gained that would be worth $20 to them professionally.

But the 600 members who want lower dues offer a challenge to the Directors and to the staff to do a better job; to make Institute membership so rewarding that every member will be thoroughly satisfied. Twenty 1935 to 1939 dollars are worth only $11.60 now, according to the latest government data, but that makes it all the more necessary for us all to appraise the value of what we buy.

To the 93 pct of Institute members who expressed a vote of confidence, so to speak, the staff, and we feel sure the Directors as well, are most appreciative and thankful.

Professional Courtesies Pay Dividends

Last sentence in a report made by Dr. M. G. Fleming, of the faculty of the Royal School of Mines, following a visit to mineral dressing plants in North America: "No less is he grateful to his colleagues in Canada and the United States for the hospitality which he received, and to the companies for their farsighted conviction that the free exchange of information is the keystone of technological progress."

Contrast this with a letter that we recently received from an AIME member on the Pacific Coast who had wished to visit a certain mineral dressing plant and had been turned down. The man was an engineer of standing who had no primary interest in visiting the plant in question, nor was he employed by a company in any way competing with the business of the company whose plant he asked to visit. He merely was taking a trip and wished to visit as many neighboring plants as possible in order to increase his knowledge of the general subject of mineral dressing.

American preeminence in many fields of mining and metallurgy has in large part developed because of free interchange of technical information, through plant visits, personal contacts, and the publication of technical papers. Such a policy is vital to the success of any professional society. In some instances it can be understood that a company might not wish to divulge a new secret process, possibly under development, to a competitor, but most AIME members believe that a strict company policy of "no visitors" is a bad one. Fortunately such a policy is continually becoming rarer in the field covered by the AIME. You can often learn from a visitor as much or more than he himself learns, and when you wish to visit his plant your conscience does not hurt you and you are more assured of a friendly welcome.

To Meet Higher Unit Costs

Financial difficulties of professional societies trying to operate under conditions of monetary inflation are not confined to the United States. AIME members have already been advised that the Canadian Institute of Mining and Metallurgy recently had to increase its dues and now comes word that the Institution of Mining and Metallurgy, of London, has had to increase its levy on members by a considerable amount. Their new dues for Members are 7 guineas ($20.58) and for Associate Members 5 guineas. This further explanation appears in the Institution's Bulletin for May: "The increases in the annual subscriptions . . . although they amount to approximately 50 pct, will not produce sufficient additional revenue to meet the greatly increased cost of the Institution's activities. No greater increase in subscription rates was thought possible, and the Council therefore decided to appeal to mining and metallurgical companies, especially those who are benefiting from the present high prices of base metals, for financial assistance. The appeal was issued in May last, and the result has been highly gratifying. The list of contributions received to date is given below." The list shows total donations to an endowment fund of £21,974, and to current revenue of £2840, with an additional contribution for each of seven years of approximately £4000.

The AIME has not cared to ask mining companies for such contributions, believing that its members prefer to pay their own way. In some instances companies pay the initiation fees or annual dues, or expenses to Institute meetings, but this is, of course, a matter between the member and his employer.

Personals

Z. W. Bartlett, J. C. Carrington, H. C. Petersen and **K. T. Price** were elected vice-presidents of the Freeport Sulphur Co.

Blandford C. Burgess was transferred on January 1 to the new Defense Materials Procurement Agency as strategic materials specialist. In May the Region III headquarters of this organization was moved to London.

L. C. Campbell was elected president of National Coal Assn. Mr. Campbell, who has been a member of the National's Board of Directors and Executive Committee for many years, is vice-president of the Coal Div. of the Eastern Gas & Fuel Associates and in charge of their extensive mining operations in West Virginia, Pennsylvania and Kentucky.

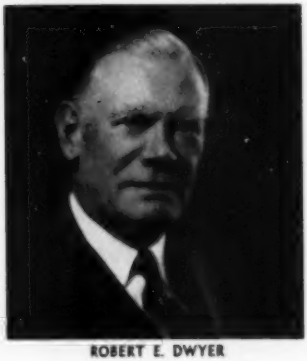
Vern H. Christoph has been transferred to Panama Canal Co., Marine Bureau, Navigation Division, Port Captains Office, as an admeasurer at Cristobal, Canal Zone.

Eugene Cline, recently graduated from the University of Kentucky, has been employed by Pond Creek Pocahontas Coal Co., at Evanston, Ky.

Sanford S. Cole, assistant manager of research at the Titanium div. of National Lead Co., received the Alumni Citation from his alma mater, Alfred University, Alfred, N. Y. This was in recognition of outstanding achievements and services in the field of ceramics which have brought honor to the institution.

U. K. Custred, recently graduated from University of Kentucky, and may be reached now at Box 87, Monterey, Tenn.

Robert E. Dwyer, executive vice-president of Anaconda since 1940, was recently elected president of this company and its subsidiaries, Chile Copper Co., Chile Exploration Co., and Andes Copper Mining Co. As president, Mr. Dwyer succeeds the late William H. Hoover who died in Butte, Mont.



ROBERT E. DWYER

Leon Dupuy, mining engineer, is the new coordinator of mineral resources studies for the U. S. Bureau of Mines, Dept. of the Interior, in Washington, D. C. For two years prior to assuming his present position on June 9, he was special assistant to Dr. C. W. Seibel, regional director, Region VI, Bureau of Mines, Amarillo, Texas.

Roland I. Ericson, professor of mining, University of North Dakota, will be in Liberia for part of the summer as a mining consultant for Liberia Mining Co.

Frank M. Estes is taking a six months professional trip through Columbia, South America.

Howard B. Gundersen was advanced from supervisor of training to assistant director of industrial relations by Kennecott's Utah copper div.

Carl Hedman, president and general manager of the Hedman Mining Co., left recently on a trip to South Dakota.

Arnold Hoffman has been named president of Towne Securities Corp.

Chester N. Howard, recently graduated from the University of Kentucky, has been employed by the Consolidation Coal Co., at Jenkins, Ky.

Lewis W. Howells is now employed as an engineer by Clinchfield Coal Corp. at Dante, Va.

Richard N. Hunt was elected to the vice presidency and directorship of United States Smelting, Refining & Mining Co. Mr. Hunt, since 1938, has been chief geologist of this company's metal mining operations and will continue in this work. He also becomes chief geologist of the oil dept.

Jack A. James resigned his position as assistant state geologist of Missouri to accept a position as senior geologist with the AMCO Exploration, Inc.

R. C. James, formerly with St. Joseph Lead Co., is now with Enterprise Exploration Pty Ltd., Melbourne, Victoria, Australia, a subsidiary of Consolidation Zinc Corp. This company does examination, exploration and diamond drilling for Consolidated Zinc.

Peter Joralemon, former assistant superintendent at New Park Mining Co., was made superintendent succeeding **Clark L. Wilson.**

Joseph C. Kieffer was appointed as assistant manager of American Smelting & Refining Co.'s operations in Salt Lake City, Utah. Mr. Kieffer has been general manager of the Spokane-Idaho Mining Co. for the past four years. He is Assistant Secretary of Columbia Section of AIME.

E. M. KLINE

E. M. Kline was made general manager of the Huntington, W. Va. works of the International Nickel Co., Inc.

P. G. Kihlstedt, formerly general superintendent of the Boliden Mining Co. at Boliden, Sweden, was appointed professor in minerals beneficiation at the Royal Institute of Technology in Stockholm. Mr. Kihlstedt has been with the Boliden Mining Co. for nineteen years and was, for most of that time, in charge of the company's ore dressing.

H. B. Lindeman has now been appointed to the position of district mining supervisor, mid-continent region, mining branch, U. S. Geological Survey.

N. Matheson has resigned from the board of British Oilfield Equipment Co. Ltd. He will devote his full time to Associated Tube Wells Ltd., London.

Earl R. Maize has been appointed general manager of operations for the Sheridan-Wyoming Coal Co., Inc., Monarch, Wyo.

William George McEvilly, sales representative for the Atlas Powder Co., is now attached to the New York office. He had been located in Chicago for the same firm.

W. D. McMillan is on loan by Region IV of the Bureau of Mines to supervise an extensive exploration and development program on the lateritic nickel deposits of eastern Cuba. This program is being carried out by the Bureau of Mines under an agreement with Defense Materials Procurement Administration and is expected to last six months.

Clinton L. Miller, mine superintendent Mt. Hope mine, Warren Foundry & Pipe Co., since July 1950, has resigned to accept a position as underground superintendent with Vermont Copper Co., South Strafford, Vt.

Earl C. McKnight is now employed as a geologist for the Standard Oil Co. of Calif., Los Angeles.

Jack A. Merritt, recently graduated from the University of Kentucky, has been employed by United States Steel Co., at Lynch, Ky.

Morris V. Mielke has been appointed superintendent in charge of Oliver Iron Mining Division's Extaca plant at Virginia, Minn., Mesabi iron range. Formerly assistant concentration engineer assigned to Oliver's Research Laboratory at Duluth, Mr. Mielke was transferred to Virginia in April 1951 and has been active in developing and directing preliminary operations at the experimental taconite agglomeration plant.

Emil Mosonyi is no longer president of the Cia. Minera Sierra Juarez since the firm has transferred their properties to another company.

Carl G. Morgenstern is now with the Bertha mineral div. of the N. J. Zinc Co., Austenville, Va.

Fred A. Orleans is president of the Cia. Orleans, S. A., Mexico, D. F.

Melvin H. Ott is now associated with the Hanna Coal Co.

W. C. Page, vice president and general manager of western operations of United States Smelting, Refining & Mining Co., was elected to the directorate.

Ernest Newton Patty, president and general manager of Alluvial Golds, Inc., Gold Placers, Inc., and Yukon Gold Placers, Ltd., is presently in Alaska and Yukon Territory.

George Remarcke has joined the M. A. Hanna Co., Cooley, Minn. as mining engineer.

Irving Rapaport has accepted the position of superintendent, Hanosh Mines, Inc., Grants, N. Mex. He had been project supervisor, Grants district, U. S. Atomic Energy Commission.

E. G. Ross, mine superintendent for the Homestake Mining Co., since 1940, and with over 43 years employment with the company has retired and has been succeeded by **C. N. Kravig.**

Leo H. Saarela has been appointed regional mining supervisor in charge of the new USGS office, conservation div., at Anchorage, for the territory of Alaska.

H. Rush Spedden has accepted a position as research mineral engineer with Union Carbide & Carbon Research Laboratories, Inc., at Niagara Falls, N. Y., where he will be leader of the group working on minerals beneficiation problems. Up to this time he was associated with Professor A. M. Gaudin at the Massachusetts Institute of Technology as assistant professor of mineral engineering.

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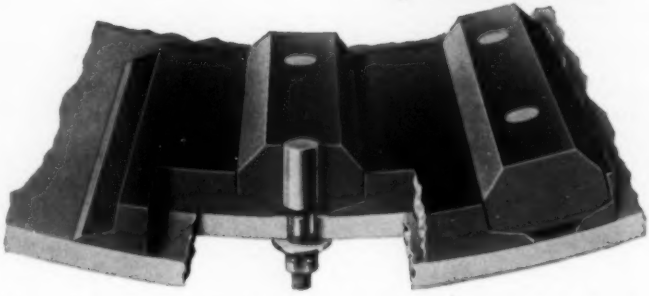

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Save valuable grinding space. Because of the strength and resistance to breakage of the rolled steel from which U·S·S Lorain Rolled Plate Linings are made, plates of reduced thickness can be used, thereby increasing the usable diameter of the mill . . . boosting output.

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UNITED STATES STEEL

EDWARD S. McGLONE

Edward S. McGlone, vice president in charge of the western operations of Anaconda was elected to the post of executive vice president. **Chester H. Steele**, general manager of western mining operations was made vice president in charge of the western operations of the Anaconda Co., to succeed Mr. McGlone. Mr. Steele is Chairman of the Montana Section of AIME.

Louis Ware, president of International Minerals & Chemical Corp., received a Doctor of Science degree at the commencement exercises of the University of Kentucky. Mr. Ware was born in Somerset, Ky., and graduated from the College of Mining Engineering at the University of Kentucky in 1917.

Benj. N. Webber, mining geologist, has returned from South America where he spent two years as consultant in problems of economic geology to the British Guiana Geological Dept. and Department of Lands and Mines. His present address is 1211 E. Willetta St., Phoenix, Ariz.

CLYDE W. WEED

Clyde W. Weed was elected vice president in charge of operations of Anaconda, and vice president of Chile Copper Co., Chile Exploration Co., and Andes Copper Mining Co.

Lewis E. Young, consulting mining engineer, has been elected an honorary member of the Institution of Mining Engineers, London, England. At present there are four honorary members of the Institution of the national engineering society of the British coal mining industry. Mr. Young served as president of AIME in 1949.

Clark L. Wilson was named to the newly created post of first vice president and manager of operations of New Park Mining Co. Mr. Wilson was also reelected a director of the company. He is Vice Chairman of Utah Section of AIME.

Wayne Bolitho, mining engineer with the Jones & Laughlin Ore Co., Star Lake, N. Y., has resigned and is with his father, E. C. Bolitho, consulting engineer, Ely, Minn.

Joseph J. Younger, recently graduated from University of Kentucky, has been employed at Tennesse Coal, Iron & RR Co.

Allan James was appointed assistant general superintendent of Warren Foundry & Pipe Co., Dover, N. J. **Koehler Stout** was appointed mine captain, **Ken Winslow,** assistant mine captain, **Jack Haien,** chief engineer, and **Howard Buckingham,** development foreman.

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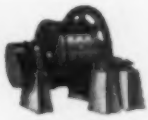

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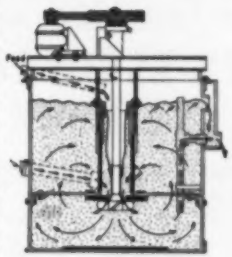

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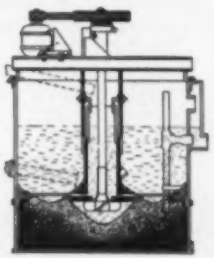

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- Our records indicate a pretty good margin in favor of your bits.
- The first Ascolite bit you sent me worked fine . . . please send me six more . . .
- . . . greatly pleased . . . find them more serviceable than other pre-set bits tried.
- . . . drilled over 500 feet in ground where the average for hand-set bits is 110 feet . . .
- The bits were . . . unusually satisfactory and it is desired to obtain four new bits like them.
- . . . shows a considerable saving . . . over our own cast-set bit . . . we wish to have four more made up.
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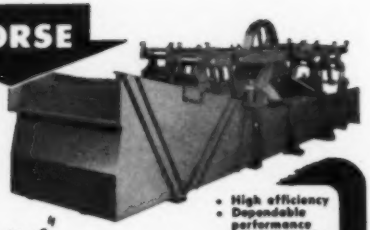

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"for efficient screening of damp materials"

INCREASE PRODUCTION
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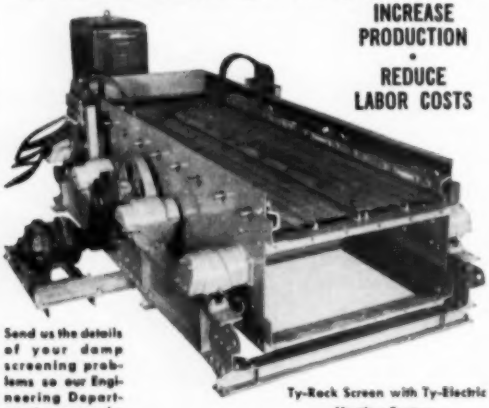

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ME8

Obituaries

Russell C. Johnson (Member 1920) died Dec. 3, 1951. Mr. Johnson was mine surveyor with Tennessee Copper Co. at Ducktown, Tenn. and was made shift boss of this company. He was mine surveyor and mine foreman at Cia Minera Asarco at Santa Barbara, Chih., Mexico. Mr. Johnson was made general mine foreman of Cia Minera Asarco at Parral, Chih., and in 1930 was made assistant superintendent. In April 1934 he was made superintendent of Santa Eulalia Unit, AS&R Co. in Chihuahua, Chih., Mexico. He was later affiliated with Northern Peru Mining Co., in Lima, Peru as managing director of this company. Born in Quincy, Mass., on May 19, 1900, he attended the Massachusetts Institute of Technology.

George H. Jones (Member 1944) has recently died. In 1911 he was employed by an engineering company at Shamokin, Pa. Mr. Jones joined the Trenton Coal Co. in 1915 as general manager. He became associated with the By-Product Coal Co., Wheelwright, Ky. for three years and in 1931 joined the Stevens Coal Co. as general manager. Mr. Jones was appointed vice-president in 1939.

H. M. Lavender (Member 1939) general manager of the Phelps Dodge Corp., Douglas, Ariz. died on Mar. 21, 1952. Mr. Lavender was born at Scotland, S. D., on Oct. 31, 1890. He attended the Colorado School of Mines and graduated in 1916 with the degree of E.M. He was engaged in war service and several jobs from 1916 to 1924. He accepted a position with the Calumet & Arizona Mining Co. as a miner. He was made shift boss, foreman, and chief engineer, successively. Mr. Lavender was promoted to mine superintendent at Bisbee. In 1931 the Calumet firm was absorbed by the Phelps Dodge Corp. and Mr. Lavender became assistant to the vice-president and general manager. In 1937 he was appointed general manager of all western operations.

NECROLOGY

Date Elected	Name	Date of Death
1948	Richard C. Badger	Unknown
1938	F. Bellamy	March 1951
1944	Walter G. Crichton	May 21, 1952
1936	Enrique P. de Romana	July 1950
1937	Wallace C. Devereaux	June 21, 1952
1949	Everett M. Gardner	May 1951
1938	V. Gregor	Apr. 30, 1952
1920	Marcus A. Grossmann	May 21, 1952
1950	W. H. Hoover	June 6, 1952
1901	Herbert A. Megraw	Nov. 3, 1951
1928	William J. Menke	Apr. 24, 1952
1908	J. C. Nicholls	May 28, 1952
1939	W. A. Odgers	Aug. 24, 1951
1952	Karl N. Ramstead	June 2, 1952
1892	John Rice	May 22, 1952
1938	Philip R. Ringuiet	November 1951
1944	Durward R. Schooler	May 30, 1952
1894	Ralph H. Sweetser	June 29, 1952
1891	J. S. Unger	May 15, 1952
1945	Gerald J. Weckmueller	June 4, 1952

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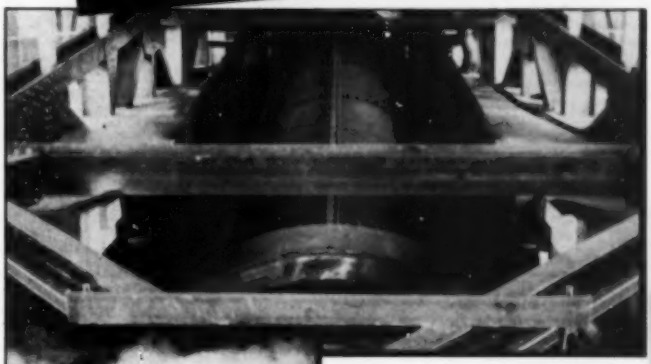

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48

—Coming Events—

Sept. 3-6, AIME, Fall Meeting, Industrial Minerals, Minerals Beneficiation, Mining, Geology, & Geophysics, Iron and Steel, and Coal Div., Palmer House, Chicago.

Sept. 3-13, AIME, Chicago Section, Centennial of Engineering, Chicago.

Sept. 5-6, Engineers' Council for Professional Development, annual meeting, Hotel Sheraton, Chicago.

Sept. 8-15, International Geologic Congress, Algiers.

Sept. 11-13, American Institute of Chemical Engineers, Palmer House, Chicago, Ill.

Sept. 18, AIME, Utah Section, Newhouse Hotel, Salt Lake City.

Sept. 22-25, American Mining Congress, Metal and Nonmetallic Mining Convention and Exposition, public auditorium, Denver.

Sept. 23-25, Institution of Mining and Metallurgy, symposium on mineral dressing, Royal School of Mines, London.

Sept. 30, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Sept. 30-Oct. 3, Iron and Steel Exposition, Cleveland Public Auditorium.

Oct. 3, AIME, National Open Hearth, Southern Ohio Section, Deshler-Wallick Hotel, Columbus, Ohio.

Oct. 10, AIME, Eastern Section, National Open Hearth Steel Committee, Harwich Hotel, Philadelphia.

Oct. 20-22, AIME, Institute of Metals Div., fall meeting with National Metal Congress, Hotel Adelphia, Philadelphia.

Oct. 24, Illinois Mining Institute, annual meeting, Hotel Abraham Lincoln, Springfield, Ill.

Oct. 28, Assn. of Consulting Chemists and Chemical Engineers, Inc., annual symposium, Hotel Belmont Plaza, New York.

Oct. 30-31, AIME, Fuels Conference, Coal Div.; ASME, Fuels Div., Bellevue-Stratford, Philadelphia.

Nov. 4, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Nov. 6-8, New Mexico Mining Assn. and **International Mining Days**, joint convention, Alvarado Hotel, El Paso.

Nov. 18, AIME, Buffalo Section, National Open Hearth Steel Committee, Hotel Statler, Buffalo.

Nov. 19, American Mining Congress Coal Div. Conference, Wm. Penn Hotel, Pittsburgh.

Nov. 20-21, American Society for Quality Control, mid-west conference, Claypool Hotel, Indianapolis.

Dec. 2, American Mining Congress, annual membership meeting, University Club, New York.

Dec. 4-6, AIME, Electric Steel Furnace Conference, Hotel William Penn, Pittsburgh.

Dec. 7-10, American Institute of Chemical Engineers, annual meeting, Hotels Cleveland and Carter, Cleveland.

Dec. 8, AIME, Arizona Section, all-day meeting, Tucson.

Feb. 16-19, 1953, AIME, annual meeting, Statler Hotel, Los Angeles.

Mar. 16-20, National Assn. of Corrosion Engineers, annual conference and exhibition, Hotel Sherman, Chicago.

Apr. 12-May 23, Empire Mining and Metallurgical Congress, Australia-New Zealand.

Apr. 20-22, AIME, National Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Hotel Statler, Buffalo.

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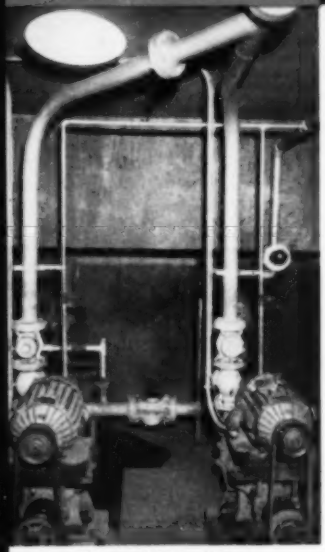

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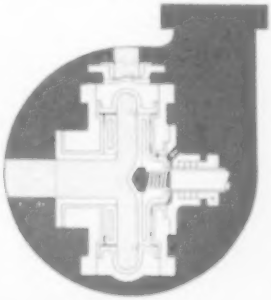

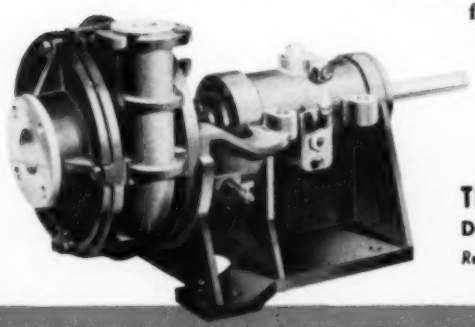

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